International Journal of Animal Science, Husbandry and Livestock Production ISSN: 2141-5191 Vol.1 (4), pp. 095-104, December, 2014. Available online at www.advancedscholarsjournals.org 

*Full Length Research Paper*

# The Impact of macroclimatic factors on Milk production and reproductive efficiency of Holstein Friesian × Deoni crossbred cows

**Dhoni Khan**

Department of Animal Science, Anna University, Chennai,India.
E-mail:Dhoni123@gmail.com

Accepted 17 November, 2014

**This study was undertaken to evaluate the effects of different macro climatic variables on milk production and reproduction efficiency of Holstein Friesian × Deoni crossbred cows. Data of 256 HF × Deoni crossbred cows with 1485 total records of lactation and the meteorological data over a 30-year period (1981 to 2010) were obtained from Marathwada Agricultural University Cattle Cross Breeding Project and the University Meteorological Observatory Weather Station, respectively. The parameters used as indicators of milk production and reproduction performance in this study were lactation milk yield, lactation length, dry period and inter calving period. They were plotted against the monthly climatic variable for regression analysis. It was observed that maximum temperature, maximum humidity, bright sunshine hours and maximum temperature humidity index exhibited negative and significant regression result with lactation milk yield and lactation length. All the considered climatic variables accounted for 28 and 21% direct variation on lactation milk yield and lactation length as verified by the value of coefficients of determination ($R^2$). In contrast, maximum temperature, maximum humidity, wind speed and maximum temperature humidity index showed positive and significant regression on dry period and inter calving period. All the considered climatic variables accounted for 25 and 23% direct variation on dry period and inter calving period, respectively. The summary of the meteorological data confirmed that there were high values of temperature humidity index for considerable months yearly, which suggested that most crossbred cows were exposed to the negative effects of heat stress. Hence, other productive and reproductive strategies like improving environmental, productive and reproductive management of cows are needed to reduce the adverse effect of heat stress.**

**Key Words:** Productive and reproductive traits, milk loss, climatic variables, heat stress.

## INTRODUCTION

Climate change has important effects on the role of livestock, both directly and indirectly. The direct effects involve heat exchanges between the animal and its environment that are linked to air temperature, humidity, wind-velocity and thermal radiation. These linkages have bearing on the physiology of the animal and influence animal performance (e.g., growth, milk production and reproduction) and health. Alterations in the factors arising from climate change like quantity and quality of feed and fodder resources such as pastures, forages, grain and crop residues and the severity and distribution of livestock diseases and parasites have indirect but significant bearing on the animal productivity (Sere et al., 2008).

Heat stress in dairy cows leads to decline in milk production and fertility. Milk production and reproduction losses during the summer substantially influence the economic potential of dairy cattle.

Heat stress has also been reported to affect the growth rates, feed intake and feed conversion efficiency in dairy cows (Wang et al., 1993; Sindhe et al., 1990). The reproductive function (like conception rates and calving intervals) is also severely affected by heat stress (Drost et al., 1999).

Hyperthermal stress increases body temperature and compromises the uterine environment, thus reducing the likelihood of embryo implantation. It also leads to a high rate of embryonic mortality: this is one of the main causes of poor reproductive performance during summer (Rivera and Hansen, 2001).

Heat stress in dairy cows is caused by a combination of environmental factors (temperature, relative humidity, solar radiation and air movement). Among all environmental stressors, the temperature and the relative humidity are the major factors, which affect the productive and reproductive performance of dairy cows. The effect of heat stress is caused by high ambient temperature and high relative humidity (Kadzere et al., 2002).

Heat stress poses formidable challenge to the development of livestock sector in India. The anticipated rise in temperature over the entire country resulting from climate change is likely to make worse the heat stress in dairy animals, adversely affecting their productive and reproductive performance, and hence reducing the total area where high yielding dairy cattle are to be economically reared. In addition, when high temperature is associated with decline in rainfall or in increased evapotranspiration, it aggravates the feed and fodder shortage (Sirohi and Michaelowa, 2004).

In most parts of the country, the hot season is relatively long and there is intense radiant energy for an extended period, generally with presence of high relative humidity. The mean summer (April to June) temperature of India ranges from 25 to 45°C in most parts of the country. Crossbred cows, which are high yielders and more economic to farmers, are more susceptible to heat stress as compared to local cows and buffaloes. The proactive management counter measures during heat stress (e.g. providing sprinklers or changing the housing pattern etc.) or animal nutrition strategies to reduce excessive heat loads are often expensive and beyond the means of small and marginal farmers who own most of the livestock (Upadhyay et al., 2009)

A case study reported by Upadhyay et al. (2009) indicated that increased heat stress associated with global climate change, causes distress to dairy animals and possibly affect milk production. They have also been estimated that India loses 1.8 million tonnes of milk production annually, amounting to over 650 million USD due to heat stress in different parts of the country. It is estimated that global warming will further negatively influence milk production more than 15 million tonnes by 2050.

Marathwada Agricultural University has taken a project for improvement of Deoni cattle breed (Figure 1) by cross breeding local Deoni cows with Holstein Friesian. The success of dairy production in general and crossbreeding programmes in particular needs to be monitored regularly by assessing the productive and reproductive performance under the existing management system.Thus, characterizing the environmental conditions to which these Holstein Friesian × Deoni Crossbred cows (Figure 2) exposed might help to properly anticipate and adapt dairy farming in specific area. The present study was planned and aimed to assess the effect of heat stress on performance of crossbred cows.

## MATERIALS AND METHODS

### Study area

This study was conducted at Marathwada Agricultural University (MAU), Cattle Cross Breeding Project (CCBP), India. The university is located at an altitude of 407 m a.s.l. It is situated between 17° 35' N and 20° 40' N latitude and between 70° 40' E and 78° 15' E longitude. The climate of the region is semi arid while; on seasonal basis, it oscillates from humid to sub humid in monsoon, sub humid to semiarid during post-monsoon and hot and dry in summer. Thermohydrologically, monsoon season is warm humid, post-monsoon is cold and sub humid, summer is hot and dry along with dry cold winter.

The mean daily maximum temperature varies from 29.1°C in December to 42.5°C in May. The mean daily minimum temperature varies from 6.9°C in December to 25.4°C in May. The relative humidity ranges from 11 to 90%. Normally, the summer is hot and general dryness persists throughout the year except during south-west monsoon. The region is essentially a subtropical one and it comes under assured rainfall zone with an average rainfall of 900 mm spread in about 70 rainy days mostly received from June to September.

### Management of animals

The management of animals at CCBP becomes identical with variation due to reasons beyond control. The daily routine management activity for lactating animals starts at 8 a.m. After calving, the calves remain with their dams for about 5-7 h. The calves were then weighed, tagged and bucket milk fed twice a day until weaning. All the calves were separated from their dam at birth and weaned at about 3 months of age. The milk recording started after 4th day from calving. The dams remained in barn for the first five days during which they were provided with green fodder, concentrate meal, and transferred to the milking herd afterwards. Cows were hand-milked twice a day, early in the morning (6:00-7:00 am) and late in the afternoon (5:00-6:00 pm) after feeding concentrate mixture regularly. The cows were allowed for grazing infallow land from 9.00 a.m. to 5.00 p.m. on a regular basis. However, in summer season (March-June) the cows were allowed to graze from 9.00 a.m to 12.00 a.m. after that the animals were tied and stall-fed with required quantities of dry and green fodder under the shed.

All animals were routinely checked for any incident of health problem and treatments were given if any abnormality exists. Additionally, animals were regularly vaccinated against major diseases such as FMD, Black Leg and Haemorrhagic Septicaemia. The milking cows were washed and groomed regularly and fed individually. The project used teaser bull for regular heat detection. Upon heat detection, cows were mated naturally to a bull. From conception up to seven months of pregnancy, cows were grazed on natural pasture after which they are were kept indoor and offered roughage and concentrate feed.

For this study, data of 256 Holstein Friesian (HF) × Deoni crossbred cows (1981 to 2010) with 1485 total records of lactation and cows having at least three offspring were selected for analysis. Meteorological data (1981 to 2010) were obtained from the university meteorological observatory weather station. The complete year was divided into 4 seasons. The four seasons are winter (December-February), summer (March-May), monsoon (June-September) and post monsoon (October-November).

#### Determination of temperature humidity index (THI)

Heat stress is commonly assessed by the THI, because the primary environmental factors that produce heat stress are temperature and humidity. THI is a useful and easy way to assess the risk of heat stress. It is suggested as an indicator of the thermal climatic conditions. This index is widely used in hot areas worldwide to assess the impact of heat stress on dairy cows. An environment is generally considered stressful for cattle when the THI exceeds 72 and when THI is at or above this level, adverse heat stress effects are expected (Johnson, 1987). THI is calculated according to National Research Council (NRC) (1971) recommended equation:

$$THI = 0.72\ (Tdb + Twb) + 40.6$$

Tdb = dry bulb temperature (°C); Twb = wet bulb temperature (°C).

Determined THI values were used to identify heat stress seasons and to examine the monthly variation of THI. The classification (None, mild, moderate, severe and danger stress level) reported by Du Preez et al. (1991) was adopted to quantify the intensity of heat stress.

To investigate the effect of macro climatic variables on milk yield and reproductive traits the data were analyzed by using multiple regression model. The main climatic variables were also compiled as monthly minimum and maximum temperature, monthly minimum and maximum relative humidity, monthly wind speed (km/h), monthly sunshine (h) as well as monthly minimum and maximum THI.

Data were analyzed by using the statistical analysis system (SAS, 2002) software programme. The following regression model was utilized to study the effect of different independent variables (climatic factors) on lactation milk yield, lactation length, dry period and inter calving period:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + uij$$

Where, Y is dependent variable; X is independent variable; a is constant; b is coefficients of X and uij is error term

This multiple regression equation describes an average relationship between dependent and independent variables, which is used to predict the dependent variables. The variability of the model was tested with the help of coefficient of multiple determinations ($R^2$). The significant of $R^2$ was tested with 'F' test and the significance of individual partial regression coefficient was tested with student 't' test.

To determine the role of various climatic factors in the variation of milk production and reproductive traits, stepwise regressions were undertaken based on the contribution of different climatic variables. Basically, regression helps to estimate the functional relationship between the independent and dependent variables.

## RESULTS AND DISCUSSION

### Effect of climatic variables on lactation milk yield and lactation length in winter season

Average LMY and LL was recorded as 2062.72±62.56 kg and 307.84±5.78 days for cows calved in winter season. It is evident from Table 1 that maximum and minimum temperature, maximum and minimum humidity, bright sunshine hours, wind speed and maximum and minimum temperature humidity index showed positive and non-significant regression with LMY and LL in this season. All the considered climatic variables accounted for 18 and 12% variation in LMY and LL.

The value of coefficients of determination ($R^2$) also revealed non-significant level. This illustrates that winter season is the most favourable season for milk production of these crossbred cows since their maximum milk production were recorded in this season. Similar finding was reported by Barash et al. (1996). Thus, the climatic condition of this season favours the milk production of crossbred cows due to its favourable climate situation and availability of quality fodder. Therefore, it can be inferred that there was no severe heat stress in winter season in the study area.

### Effect of climatic variables on dry period and inter calving period in winter season

In winter season, the average DP and ICP was observed as 106.91±3.84 and 404.72±5.94 days, respectively. All the considered climatic variables exhibited positive and non-significant regression with DP and ICP (Table 2). All the considered climatic variables accounted for about 17 and 21% variation in DP and ICP in the season. The $R^2$ value showed non-significant level statistically, which means the effect of winter season was non -substantial on length of DP and ICP. There was a similar trend between DP and ICP in view of the fact that DP is a component of

**Figure 1.** Atypical representative of a Deoni cow at CCBP, MAU.

**Figure 2.** Atypical representative of HF × Deoni crossbred cow at CCBP, MAU.

**Table 1.** Regression coefficients for lactation milk yield and lactation length on climatic variables in winter season.

| Variable | Mean ± SE | LMY | | | LL | | |
|---|---|---|---|---|---|---|---|
| | | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 30.74±0.20 | 151.70 | 80.87 | 1.88 | 0.82 | 7.18 | 0.11 |
| Min T°C | 11.92±0.22 | 52.36 | 58.50 | 0.90 | 0.88 | 5.20 | 0.17 |
| Max Hum | 71.67±0.86 | 10.14 | 13.65 | 0.74 | 0.57 | 1.21 | 0.47 |
| Min Hum | 29.38±0.71 | 23.03 | 16.99 | 1.36 | 0.06 | 1.51 | 0.04 |
| BSH | 9.97±0.07 | 183.39 | 108.11 | 1.70 | 6.95 | 9.60 | 0.72 |
| WS | 4.05±0.13 | 19.23 | 63.15 | 0.30 | 1.33 | 5.61 | 0.24 |
| Max THI | 75.30±0.21 | 60.66 | 57.16 | 1.06 | 0.80 | 5.08 | 0.16 |
| Min THI | 59.10±0.28 | 21.36 | 36.24 | 0.59 | 2.90 | 3.22 | 0.90 |
| | | $R^2$ = 0.18 | | F value = 1.68 | $R^2$ = 0.12 | | F value = 0.52 |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

**Table 2.** Regression coefficients for dry period and calving interval on climatic variables in winter season.

| Variable | DP | | | ICP | | |
|---|---|---|---|---|---|---|
| | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 0.93 | 5.53 | 0.17 | 1.71 | 8.87 | 0.19 |
| Min T°C | 4.67 | 4.00 | 1.17 | 5.53 | 6.42 | 0.86 |
| Max Hum | 1.30 | 0.93 | 1.39 | 0.74 | 1.50 | 0.50 |
| Min Hum | 2.08 | 1.16 | 1.79 | 2.14 | 1.86 | 1.15 |
| BSH | 2.36 | 7.39 | 0.32 | 9.35 | 11.86 | 0.79 |
| WS | 5.22 | 4.32 | 1.21 | 6.51 | 6.93 | 0.94 |
| Max THI | 4.09 | 3.91 | 1.05 | 3.31 | 6.27 | 0.53 |
| Min THI | 5.43 | 2.48 | 2.19 | 2.55 | 3.98 | 0.64 |
| | $R^2$ = 0.17 | | F value = 1.30 | $R^2$ = 0.21 | | F value = 0.39 |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

ICP. Hence, winter season is the most favourable season for crossbred cows to achieve short DP and ICP as compare to the other seasons.

### Effect of climatic variables on lactation milk yield and lactation length in summer season

Average LMY and LL was recorded as 1714.97±47.75 kg and 272.84±5.78 days for cows calved in summer season. It was observed that Max T°C, BSH and Max THI showed negative and significant (P<0.05) regression while; Min T°C, Max Hum and Min THI had negative and non-significant influence with LMY and LL. However, wind speed exhibited positive and non-significant relationship on LMY and LL. This illustrated that an increase in Max T°C, sunshine radiation and Max THI could lead to decrease in LMY and LL due to negative regression (Table 3).

All the considered climatic variables in this study accounted for 33 and 26% variation in LMY and LL, respectively. The $R^2$ value showed significant level (P<0.05), which means the effect of summer season was substantial on LMY and LL. Thus, it can be inferred that there were significant effect of the selected climatic variables which means the LL was shortened by several days during extreme summer (Table 3). Furthermore, when THI was more than 72, LMY was also affected

**Table 3.** Regression coefficients for lactatio n milk yield an d lactation len gth on climatic variables in summer season.

| Variable | Mean ± SE | LMY | | | LL | | |
|---|---|---|---|---|---|---|---|
| | | b | SE of (b) | t v alue | b | SE of (b) | t value |
| Max T°C | 39.37±0.24 | -43.65 | 18.21 | -2 .40* | -15.3 5 | 5.92 | -2.59* |
| Min T°C | 21.30±0.34 | -52.52 | 43.63 | - 1.20 | -2.94 | 6.62 | -0.44 |
| Max Hum | 46.35±0.86 | -2.82 | 9.82 | - 0.29 | -0.09 | 1.49 | -0.06 |
| Min Hum | 19.10±0.53 | 11.11 | 16.89 | 0 .66 | -0.53 | 2.56 | -0.21 |
| BSH | 10.65±0.08 | -99.96 | 37.24 | -2 .68* | -12.4 8 | 5.69 | -2.19* |
| WS | 7.04±0.26 | 3.6 | 23.74 | 0 .15 | 0.74 | 3.6 | 0.21 |
| Max THI | 84.03±0.23 | -55.9 | 26.27 | -2 .13* | -13.9 6 | 5.54 | -2.52* |
| Min THI | 71.37±0.45 | -53.7 | 27.36 | - 1.96 | -0.23 | 4.15 | -0.06 |
| | | $R^2$ = 0.32 | | F value = 2.18* | $R^2$ = 0 .26 | | F valu e = 2.05* |

b = Estimated regression coef icient, LMY = lactation milk yiel , LL= lactation length, Max T°C = maximum temperature, Min T°C= mini um temperatur e, Max Hum= maximum hum idity, Min Hum = minimum humidity, BSH=bright sunshin hour, WS =wi d speed, Max Min HI = maximum temperature-humidity index, THI=minim um temperature -humidity index.

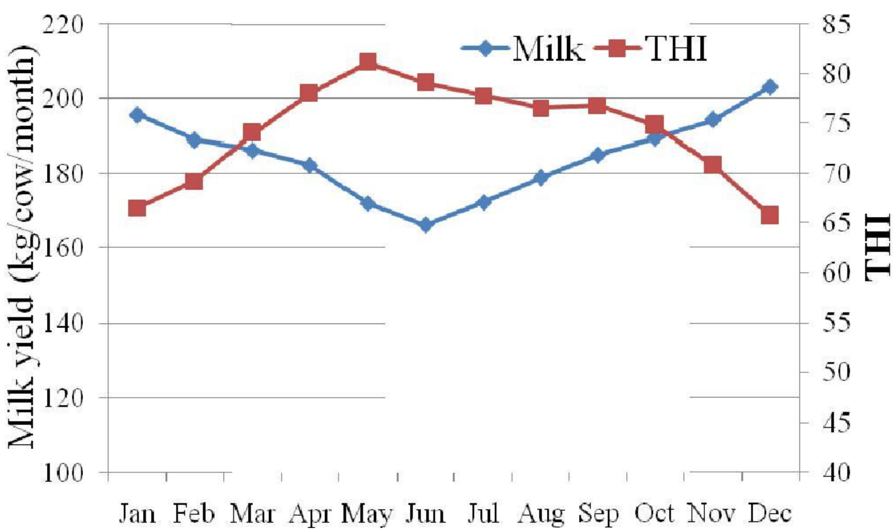


**Figure 3.** Monthly varia tion for milk pr oduction and T I from 1981-20 10.

sev erely. Similar results were reported by Mandal et al. (2002), Shivpra ad and Ramkaran (2002), Bouraoui et al. (2002), West et al. (2003), Daniel et al. (2 008) and Sin gh an Upadhyay (2009).

F igure 3 illust rates the tren d for the ov erall mean HI val ues and milk yield per co w per month. It indicates that these crossbred cows were exposed to h eat stress fr om March to Septe mber with TH I values vary ing between 74 an 81.1 (Table 5) and the lowest ilk yield w ere recorded in these months.

S imilar trends were obse ved for Egypt and Arizo na wh ere THI valu s were high er than 72 fo r four to six a nd thr ee to four mo nths, respectively (Johns on, 1985) an d a ne ative relationship betwe en milk production and HI we re clearly ob erved. Indee d, as THI inc reases from 74 to 81.1 during th e summer s eason, milk yield per co w drop down from 157.2 in Mar ch to 133.2 kg/month/co w in June. That is a decrease of about 15% which can b e largely explained by the effec t of summe r heat stress , partic ularly in Ma y and June when THI va lues are well above the critical threshold of 72 reporte by Johnso n (198 ) and Dikm en and Hansen (2009) a nd can be as high as 81.1 in Ma y (Table 5).

## Effec t of climati c variables on dry period and inter calving period in summer se ason

The average DP nd ICP were observed a 134.42±3.7 2 and 40.37±6.41 days in sum er season, respectively. t

**Table 4.** Regression coefficients for dry period and calving interval on climatic variables in summer season.

| Variable | Dry period | | | Calving interval | | |
|---|---|---|---|---|---|---|
| | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 12.74 | 5.84 | 2.18* | 14.4 | 6.24 | 2.31* |
| Min T°C | 5.03 | 3.72 | 1.35 | 2.09 | 5.73 | 0.36 |
| Max Hum | 1.39 | 1.29 | 1.08 | 2.48 | 1.74 | 1.43 |
| Min Hum | 6.24 | 2.21 | 2.82* | 6.72 | 2.99 | 2.25* |
| BSH | 8.83 | 5.5 | 1.61 | 3.31 | 10.14 | 0.33 |
| WS | 7.02 | 3.11 | 2.26* | 5.28 | 3.2 | 1.65 |
| Max THI | 9.43 | 4.37 | 2.16* | 15.53 | 6.96 | 2.23* |
| Min THI | 2.06 | 3.58 | 0.58 | 2.29 | 3.84 | 0.60 |
| | $R^2$ = 0.27 | | F value = 2.21* | $R^2$ = 0.24 | | F value = 2.13* |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

**Table 5.** Summary mean meteorological data from 1981-2010.

| Month | Rain | T°C | | RH | | BSH | WS | THI | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | Max | Min | | | Max | Min | Mean |
| Jan | 0.32 | 29.98 | 11.60 | 74.85 | 31.14 | 9.85 | 3.92 | 74.80 | 58.34 | 66.57 |
| Feb | 0.18 | 32.86 | 13.49 | 63.19 | 24.48 | 10.46 | 4.62 | 77.37 | 61.19 | 69.28 |
| Mar | 0.34 | 36.81 | 17.44 | 49.64 | 19.75 | 10.59 | 5.31 | 81.53 | 66.41 | 73.97 |
| Apr | 0.21 | 40.09 | 21.58 | 42.27 | 16.95 | 10.84 | 6.36 | 84.24 | 71.73 | 77.99 |
| May | 0.63 | 41.19 | 24.88 | 47.15 | 20.61 | 10.52 | 9.47 | 86.31 | 75.97 | 81.14 |
| Jun | 5.33 | 36.35 | 23.83 | 72.06 | 43.42 | 7.22 | 10.76 | 82.44 | 75.75 | 79.10 |
| Jul | 7.30 | 32.04 | 22.48 | 82.49 | 58.50 | 4.74 | 9.41 | 80.39 | 75.20 | 77.80 |
| Aug | 7.62 | 30.66 | 22.00 | 85.03 | 63.77 | 4.69 | 8.25 | 78.99 | 74.07 | 76.53 |
| Sep | 5.85 | 31.82 | 21.73 | 84.94 | 58.13 | 6.85 | 5.88 | 79.76 | 73.79 | 76.78 |
| Oct | 2.74 | 32.51 | 18.42 | 78.45 | 43.22 | 8.99 | 4.50 | 79.40 | 70.19 | 74.80 |
| Nov | 0.75 | 30.81 | 13.85 | 75.85 | 36.42 | 9.60 | 4.24 | 76.36 | 65.26 | 70.81 |
| Dec | 0.28 | 29.36 | 10.68 | 76.96 | 32.51 | 9.59 | 3.62 | 73.72 | 57.78 | 65.75 |

was observed that Max T°C, Min Hum and Max THI exhibited positive and significant ($P<0.05$) regression whereas; Min T°C, Max Hum, BSH and Min THI revealed positive and non-significant regression with DP and ICP. All the considered climatic variables accounted for 27 and 24% variation in DP and ICP, correspondingly. The $R^2$ value showed significant level ($P<0.05$) statistically (Table 4). Thus, it could be inferred that there were significant influence of the selected climatic variables on DP and ICP in this season. This illustrates that an increase in temperature, relative humidity, sunshine radiation and THI, could lead to lengthen DP and ICP by several days (Table 4).

Similar findings were reported by Du Bois and Williams (1980), Weller and Folman (1990), Ray et al. (1992), Bouraoui et al. (2002), Jordan et al. (2002), Mishra and Joshi (2009) and Gaafar et al. (2011). Thus, calving schedules could be adjusted to minimize the adverse effect of heat stress.

## Effect of climatic variables on lactation milk yield and lactation length in monsoon season

Average LMY and LL were recorded as 1830.15±40.54 kg and 289.19±6.24 days in monsoon season, respectively. It was observed that Max T°C, Max Hum and Max THI showed negative and significant ($P<0.05$) regression while BSH and Min THI had negative and non-significant relationship with LMY and LL. However, Min T°C and Min Hum exhibited positive and non-significant regression whereas wind speed revealed positive and significant ($P<0.05$) regression on LMY. This illustrated that an increase in Max T°C, Max Hum and Max THI could lead

**Table 6.** Regression coefficients for lactation milk yield and lactation length on climatic variables in monsoon season.

| Variable | Mean ± SE | LMY | | | LL | | |
|---|---|---|---|---|---|---|---|
| | | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 32.27±0.23 | -57.37 | 22.44 | -2.56* | -8.87 | 3.79 | -2.34* |
| Min T°C | 22.51±0.12 | 62.07 | 39.47 | 1.57 | 3.28 | 4.83 | 0.68 |
| Max Hum | 81.13±0.64 | -22.82 | 10.02 | -2.28* | -6.29 | 2.92 | -2.15* |
| Min Hum | 55.96±0.94 | 6.74 | 11.34 | 0.59 | 0.55 | 1.67 | 0.33 |
| BSH | 5.87±0.15 | -20.79 | 36.6 | -0.57 | -12.42 | 5.41 | -2.30* |
| WS | 8.57±0.31 | 34.86 | 14.15 | 2.46* | 2.03 | 2.09 | 0.97 |
| Max THI | 80.39±0.18 | -71.43 | 33.25 | -2.15* | -9.47 | 4.39 | -2.16* |
| Min THI | 74.70±0.13 | -71.32 | 52.94 | -1.35 | -5.61 | 7.82 | -0.72 |
| | | $R^2$ = 0.19 | F value = 2.08* | | $R^2$ = 0.17 | F value = 2.05* | |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

**Table 7.** Regression coefficients for dry period and calving interval on climatic variables in monsoon season.

| Variable | Dry period | | | Calving interval | | |
|---|---|---|---|---|---|---|
| | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 7.86 | 3.35 | 2.35* | 9.98 | 4.71 | 2.12* |
| Min T°C | 4.65 | 4.07 | 1.14 | 1.37 | 5.74 | 0.24 |
| Max Hum | 3.49 | 1.34 | 2.60* | 4.78 | 1.89 | 2.53* |
| Min Hum | 0.76 | 1.17 | 0.65 | 0.21 | 1.65 | 0.13 |
| BSH | 5.34 | 3.78 | 1.41 | 7.08 | 5.32 | 1.33 |
| WS | 4.07 | 1.46 | 2.79** | 2.04 | 2.06 | 0.99 |
| Max THI | 9.11 | 4.46 | 2.04* | 9.36 | 4.29 | 2.18* |
| Min THI | 3.34 | 5.46 | 0.61 | 8.94 | 7.69 | 1.16 |
| | $R^2$ = 0.20 | F value = 3.47** | | $R^2$ = 0.17 | F value = 1.85 | |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

to decrease LMY and LL due to negative regression (Table 6). Similar findings under Indian condition were reported (Singh and Mishra, 1980; Shinde, 1984; Shindhe et al., 1990; Kulkarni et al., 1998; Mandal et al., 2002; Upadhyay, 2003).

All the considered climatic variables accounted for 19 and 17% variation in LMY and LL, correspondingly. The $R^2$ value showed significant level (P<0.05) statistically. Thus, it can be inferred that there were significant influence of the selected climatic variables on LMY and LL in monsoon season (Table 6).

### Effect of climatic variables on dry period and inter calving interval in monsoon season

Those cows calved in this season achieved an average DP and ICP as 117.58±4.09 and 431.78±5.53 days, respectively. It was observed that Max T°C, Max Hum and Max THI exhibited positive and significant (P<0.05) regression whereas, Min T°C, Min Hum, BSH and Min THI revealed positive and non-significant regression with DP and ICP. In contrast, WS showed positive and significant (P<0.05) regression with DP (Table 7).

**Table 8.** Regression coefficients for lactation milk yield and lactation length with climatic variables in post-monsoon season.

| Variable | Mean ± SE | LMY | | | LL | | |
|---|---|---|---|---|---|---|---|
| | | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 31.67±0.17 | 119.5 | 108.7 | 1.10 | 28.61 | 10.95 | 2.61 |
| Min T°C | 16.38±0.38 | 14.83 | 54.2 | 0.27 | 3.99 | 5.46 | 0.73 |
| Max Hum | 77.15±0.71 | 14.71 | 18.77 | 0.78 | 1.18 | 1.89 | 0.62 |
| Min Hum | 39.82±1.17 | 3.52 | 16.08 | 0.22 | 1.48 | 1.62 | 0.91 |
| BSH | 9.30±0.12 | 130.17 | 109.8 | 1.19 | 8.38 | 11.07 | 0.76 |
| WS | 4.37±0.16 | 19.6 | 59.09 | 0.33 | 4.93 | 5.95 | 0.83 |
| Max THI | 77.88±0.23 | -190.16 | 84.72 | -2.24* | -27.69 | 8.53 | -3.25** |
| Min THI | 67.72±0.45 | 11.35 | 32.26 | 0.35 | 2.4 | 3.25 | 0.74 |
| | | $R^2$ = 0.14 F value = 1.08 | | | $R^2$ = 0.12 | | F value = 1.52 |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS = wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

**Table 9.** Regression coefficients for dry period and calving interval on climatic variables in post-monsoon season.

| Variable | DP | | | ICP | | |
|---|---|---|---|---|---|---|
| | b | SE of (b) | t value | b | SE of (b) | t value |
| Max T°C | 16.74 | 9.31 | 1.80 | 9.87 | 15 | 0.66 |
| Min T°C | 2.73 | 4.64 | 0.59 | 1.27 | 7.48 | 0.17 |
| Max Hum | 2.53 | 1.61 | 1.57 | 1.34 | 2.59 | 0.52 |
| Min Hum | 0.35 | 1.38 | 0.25 | 1.13 | 2.22 | 0.51 |
| BSH | 8.58 | 9.41 | 0.91 | 0.2 | 15.16 | 0.01 |
| WS | 9.58 | 5.06 | 1.89 | 15.51 | 8.16 | 1.90 |
| Max THI | 16.92 | 7.26 | 2.33 | 7.77 | 11.69 | 0.66 |
| Min THI | 4.53 | 2.76 | 1.64 | 4.13 | 4.45 | 0.93 |
| | $R^2$ = 0.23 | F value = 1.30 | | $R^2$ = 0.21 | F value = 0.99 | |

b = Estimated regression coefficient, LMY = lactation milk yield, LL= lactation length, Max T°C = maximum temperature, Min T°C= minimum temperature, Max Hum= maximum humidity, Min Hum = minimum humidity, BSH=bright sunshine hour, WS =wind speed, Max THI = maximum temperature-humidity index, Min THI=minimum temperature-humidity index.

All the considered climatic variables accounted for 20 and 17% variation in DP and ICP. The $R^2$ value showed significant level (P<0.01) for DP but not for ICP statistically. Thus, it could be inferred that there were significant effect of the selected climatic variables on DP, which means the DP could be lengthen by several days due to heat stress (Table 7).

### Effect of climatic variables on lactation milk yield and lactation length in post-monsoon season

Average LMY and LL were recorded as 1970.93±54.46 kg and 304.4±7.94 days in post-monsoon season (Table 8). It was observed that all the selected climatic variables showed positive and non-significant regression while; Max THI had negative and significant relationship with LMY (P<0.05) and LL (P<0.01) in this season. All the considered climatic variables accounted for 14 and 12% variation in LMY and LL. The $R^2$ value also showed non-significant level statistically (Table 8). The LL recorded in this season was close to the recommended LL of 305-days commonly accepted as a standard. Thus, climatic condition in post-monsoon season is conducive for milk production due to favourable climate and availability of quality fodder.

### Effect of climatic variables on dry period and inter calving period in post-monsoon season

Average DP and ICP were recorded as 96.55±5.72 and 389.72±5.94 days, respectively for cows calved in post-monsoon season. It was observed that all of the climatic variables showed positive and non-significant regression with DP and ICP (Table 9). All the climatic variables considered accounted for 23 and 21% variation in DP and ICP, respectively (Table 9). The ($R^2$) value showed non-significant level statistically.

## Conclusions

This research indicates that crossbred cows were sensitive for seasonal changes on their milk production and reproduction potential. With an increase in values of climatic variables, a decline in milk production and reproduction efficiency performance was manifested for considerable months of the year due to heat stress. The summary of meteorological data confirmed that there was high value of THI in seven months (March-September) yearly, which suggested that most crossbred cows were exposed to the negative effects of heat stress, where it will be difficult for them to thrive and maintain their production and reproduction potential. Therefore, additional productive and reproductive strategies like improving environmental, productive and reproductive management of cows are needed to reduce the adverse effect of heat stress.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

### REFERENCES


Barash H, Silanikove N, Shamay A, Ezra E (2001). Interrelationships among ambient temperature, day length and milk yield in dairy cows under Mediterranean climate. J. Dairy Sci. 84(10):2314-2320. http://dx.doi.org/10.3168/jds.S0022-0302(01)74679-6

Bouraoui R, Lahmar M, Majdoub A, Belyea R (2002). The relationship of Temperature-Humidity-Index with milk production of dairy cows in a Mediterranean climate. J. Anim. Res. 51: 479-491.http://dx.doi.org/10.1051/animres:2002036

Daniel F, Walterava L, Skyeala M, Chladek G (2008). Effect of stable micro climatic on milk production of Holstein cows the 2nd and 3rd lactation. Aweth. vol. 4.PMCid:PMC2276829

Dikmen S, Hansen PJ (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment? J. Dairy Sci. 92:109-116. http://dx.doi.org/10.3168/jds.2008-1370; PMid:19109269

Drost M, Ambrose JD, Thatcher MJ, Cantrell CK, Wolfsdorf KE, Hasler JF, Thatcher WW (1999). Conception rates after artificial insemination or embryo transfer in lactating dairy cows during summer in Florida. Theriogenology 52: 1161-1167. http://dx.doi.org/10.1016/S0093-691X(99)00208-3

Du Bois PR, Williams DJ (1980). Increased incidence of retained placenta associated with heat stress in dairy cows. Theriogenology 13: 115-121.http://dx.doi.org/10.1016/0093-691X(80)90120-X

Du Preez JH, Terblanche SJ, Giesecke WH, Maree C, Welding MC (1991). Effect of heat stress on conception in a dairy herd model under South African conditions. Theriogenology 35: 1039-1049.http://dx.doi.org/10.1016/0093-691X(91)90313-3

Gaafar HMA, Abu El-Hamd MA, El- Gendy ME, Bassiouni MI, Halawa AA, Shamiah SHM (2011). Effect of heat stress on performance of Holstein Friesian cows: 2- Reproductive Performance. Researcher 3(5):94-100.

Johnson HD (1985). Physiological responses and productivity of cattle, In: Stress physiology in livestock. Basic Principles. Ed. Yousef, M.K., Boca Raton, Florida, CRC Press, 1: 4-19.

Johnson HD (1987). Bioclimatology and the Adaptation of Livestock. World Animal Science. (H.D. Johnson ed.) Elsevier Science Publ. Co., New York. 157 p.

Jordan ER, Schouten MJ, Quast JW, Belschner AP, Tomaszewski MA (2002). Comparison of two timed artificial insemination (TAI) protocols for management of first insemination postpartum. J. Dairy Sci. 85: 1002-1008. http://dx.doi.org/10.3168/jds.S0022-0302(02)74160-X

Kadzere CT, Murphy MR, Silanikove N, Maltz E (2002). Heat stress in lactating dairy cows: a review. Livest. Prod. Sci. 77 (1):59-91. http://dx.doi.org/10.1016/S0301-6226(01)00330-X

Kulkarni AA, Pingle SS, Atkare VG, Deshmukkh AB (1998). Effect of climatic factor on milk production in crossbred cow. Indian Vet. J. 75: 846-847.

Mandal DK, Rao S, Singh K, Singh SP (2002). Effect of macroclimatic factor on milk production in Friesian × Sahiwal half bred. Indian J. Dairy Sci. 55(3): 166-170.

Mishra SS, Joshi BK (2009) . Genetic and non-genetic factors affecting lactation milk constituents and yield traits in Holstein Friesian × Karan crossbred cows. Indian J. Dairy Sci. 57: 69-72.

NRC (National Research Council) (1971). A guide to environmental research on animals. Natl. Acad. Sci., Washington, DC.

Ray DE, Halbach TJ, Armstrong DV (1992). Season and lactation number effects on milk production and reproduction of dairy cattle in Arizona. J. Dairy Sci. 75: 2976-2983. http://dx.doi.org/10.3168/jds.S0022-0302(92)78061-8

Rivera RM, Hansen PJ (2001). Development of cultured bovine embryos after exposure to heat temperatures in the physiological range. J. Reproduction 121: 107-115. http://dx.doi.org/10.1530/rep.0.1210107

SAS (Statistical Analysis System) (2002). SAS Version 9.1.3, SAS Institute Inc., Cary, NC, USA.

Sere C, Zijpp AV, Persley G, Rege E (2008). Dynamics of livestock production systems, drivers of change and prospects for animal genetic resources. Anim. Genet. Resour. Inf. 42: 3–27.

Shinde SK (1984). Effect of physical environment on reproduction and production traits in crossbred cow. MSc. Thesis submitted to Kurukshtra University Kurukshtra.

Shindhe S, Taneja VK, Singh A (1990). Association of climate variables and production and reproduction traits in crossbreds. Indian J. Anim. Sci. 60:81-85.

Shivprasad B, Ramkarm Singh (2002). A measure of persistency based on inflection point on lactation curve. Indian J. Anim. Sci. 72(7): 595-598.

Singh AS, Mishra P (1980). Physiological and economic traits of Holstein Friesian, Jersey, crossbred and Hariana cows in hot and humid environment. Indian J. Dairy. Sci. 33:174-181.

Singh SV, RC Upadhyay (2009). Thermal stress on physiological functions, thermal balance and milk production in Holstein Friesian × Sahiwal crossbred cows. Indian Vet. J. 86: 141-144.

Sirohi S, Michaelowa A (2004). CDM Potential of Dairy Sector in India. HWWA Discussion Paper No. 273. Hamburg Institute of International Economics. ISSN 1616-4814.

Upadhyay RC (2003). Strategies for alleviating climatic stress in animal. All India Dairy Husbandry Workshop, NDRI, Karnal.

Upadhyay RC, Ashutosh, Raina VS, Singh SV (2009). Impact of Climate Change on reproductive functions of cattle and buffaloes. In: Global Climate Change and Indian Agriculture (Edited by P.K. Aggarwal). Published by ICAR, New Delhi. pp.107-110.

Wang JN, Lu SY, Hu YC, Yang TN (1993). Effect of Evaporative cooling on lactation and reproduction of Holstein cow in summer. J. Chin. Soc. Anim. Sci. 22:163-173.

Weller JI, Folman Y (1990) . Effects of calf value and reproductive management on optimum days to first breeding. J. Dairy Science 1318. http://jds.fass.org/cgi/reprint/73/5/1318

West JW, Mullinix BG, Bernard JK (2003) . Effects of Hot, Humid Weather on Milk Temperature, Dry Matter Intake, and Milk Yield of Lactating Dairy Cows. J. Dairy Sci. 86: 232–242.http://dx.doi.org/10.3168/jds.S0022-0302(03)73602-9