

Original Research Article

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Effect of Climatic Factors on Milk Production of Triple Crossbred (Holstein Friesian 25 % X Jersey 25 % Kankrej 50 %) Cows

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ABSTRACT

Data on 77, 010 daily milk yield (DMY) records of 247 lactations of crossbred cows over a period of 12 years from 2003-2014 were utilized for present experiment was conducted at Livestock Research Station (LRS), Collage of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India. Correlation and regression analysis were carried out with Standard week (meteorological standard week) wise data of milk yield and meteorological data (minimum temperature (MIN T), maximum temperature (MAX T), morning relative humidity(RH1), afternoon relative humidity(RH2), morning vapor pressure (VP1), afternoon relative humidity (VP2), wind speed (WS),bright sun shine hour(BSS), rain fall(RF) and evaporation rate (EP)) of 12 years by SAS (Statistical Analysis Software) programme (version 9.3). The overall average DMY of cross bred cows during 12 years period (2003-2014) was 8.73±0.26 kg. Maximum DMY was recorded during March (10.15±0.52 kg) and minimum was recorded during September (7.72±0.34 kg). Average DMY ranged from 4.39±0.37 to 13.83±0.55 kg from 12 year 2003 to 2014. Month of year had significant (P<0.05) effect on daily milk production. Correlation between Standard week wise milk yield data (of all 12 years) and MAX T was positive (0.1893) and significant, Whereas, RH1, RH2 and VP2 had negative and highly significant. RF was also found to be negative but significantly correlated. EP and BSS had positive and highly significant correlation with weekly average MY. There was no significant correlation among weekly average MY and MIN T and VP1 but WS was significantly correlated with average weekly MY. All the partial regression coefficients for independent variables were found significant except RH1, RF and VP2 but coefficient of determination (R²) was found very low (0.1652). Stepwise regression analysis showed that the partial regression coefficient of MIN T and BSS were found negative and highly significant whereas, partial regression coefficient of RH1, WS and EP were found positive and highly significant. The R² of final model was 0.66 this indicated that the weather parameters (RH1, WS and MIN T) explained about 66% variations in average standard week wise milk production (averaged out of all 12 years data). The partial regression coefficient (R²) of MIN T and RH1 were found negative and significant indicating negative impact on average standard week wise milk yield whereas that of WS had positive impact on average standard week wise milk yield.

Keywords

Triple crossbred,
Milk, Climatic
factors

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Introduction

Global warming is the increase in average temperature of Earth's near-surface air and oceans since the mid-20th century and its projected continuation. According to Fourth Assessment Report, global surface temperature increased by $0.74 \pm 0.18^\circ\text{C}$ during the 20th century (IPCC, 2007). Major impacts on global warming in nature are increase in global temperatures which will result in glacial melting and worldwide sea level rise, flooding and drought, changes in the frequency and intensity of extreme weather events, changes in agricultural yields, reduced summer stream flows, species extinctions and increase in the range of disease vectors etc. Climate change affects milk production because of the sensitivity of dairy cows to changes in climatic factors. Excessive heat and humidity causes heat stress in dairy cows, which results in reduced milk production (Maugar *et al.*, 2014). High environmental temperature greatly influence on reproductive performance of dairy cows. If body temperature exceed 40°C than damage developed follicles and become non – viable. Different environmental factors like temperature, humidity, wind speed, radiations influence on reproductive efficiency like decrease oocyte, conception rate and fertility and also decrease in milk production (Sheikh *et al.*, 2017). Environment directly and indirectly influences survival and productivity of dairy animals (Thatcher and Collier, 1981). Major environmental factors include air temperature, humidity, WS, wind direction (WD), solar radiation (SR), RF and evaporation (Folk, 1974). Effect of global warming in dairy cows is a result of one or a combination of environmental factors like temperature, relative humidity (RH), SR and air movement. Among all environmental stressors, temperature and relative humidity are two major factors which affect the productive and reproductive performance of

dairy cows. A combination of the temperature and RH has more pronounced adverse effect on livestock production rather than their individual effects. Heat stress can be simply defined as the point where the cow cannot dissipate an adequate quantity of heat to maintain body thermal balance. The effect of heat stress is caused by high ambient temperature and high relative humidity (Kadzere *et al.*, 2002). At high temperature several physiological changes occur in dairy cow and they attempt to facilitate heat dissipation, if they failure of homeostasis of high temperature may lead to reduce productivity or even death (Kamal *et al.*, 2018).

Materials and Methods

DMY records of crossbred animals (Holstein Friesian 25 % X Jersey 25 % Kankrej 50 %) maintained on LRS were utilized for present study. The daily meteorological records were collected from meteorology department, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. A total 77,010 daily milk yield records of 247 lactations completed on the farm from 2003 to 2014 were statistically analyzed as per the procedures described by Snedecor and Cochran (1980). Correlation and regression analysis were carried out with Standard week (meteorological standard week) wise data of milk yield and meteorological data (MIN T, MAX T, RH1, RH2, VP1, VP2, WS, BSS, RF and EP) of 12 years (622+2 weeks, last 2 week's milk data of 2014 were ignored as there was no observation) were analyzed by SAS (Statistical Analysis Software) programme (version 9.3). These data were further used for stepwise regression analysis by SAS programme. In final model, Standard week wise data of all 12 years were averaged out over meteorological standard weeks and these data were further used for step wise regression analysis.

Results and Discussion

The overall mean DMY of cross bred cows during 12 years period (2003-2014) was 8.74 ± 0.26 kg. Monthly mean DMY of crossbred cows were 9.08 ± 0.65 , 9.67 ± 0.75 , 10.15 ± 0.52 , 9.78 ± 0.33 , 9.38 ± 0.37 , 9.09 ± 0.32 , 8.66 ± 0.23 , 7.99 ± 0.31 , 7.72 ± 0.34 , 7.56 ± 0.44 , 7.78 ± 0.48 and 7.97 ± 0.61 kg with from January to December. Maximum DMY was recorded during March (10.15 ± 0.52 kg) and minimum was recorded during September (7.72 ± 0.34 kg). Similarly yearly mean DMY of crossbred cows was 7.66 ± 0.83 , 7.82 ± 0.52 , 7.44 ± 0.17 , 8.60 ± 0.29 , 8.67 ± 0.28 , 8.34 ± 0.17 , 7.72 ± 0.21 , 8.94 ± 0.46 , 10.18 ± 0.31 , 10.34 ± 0.31 , 10.03 ± 0.31 , 9.15 ± 0.85 and 8.74 ± 0.26 kg with from 2003 to 2014. Average DMY ranged from 4.39 ± 0.37 to 13.83 ± 0.55 kg. Month of year had significant ($P < 0.05$) effect on daily milk production. Epaphras *et al.*, (2004) reported that average DMY of cows was highest during April and May and it dropped during December to February. Similarly, Bakir and Keygisiz (2013) reported that monthly average MY was maximum during July and August and minimum from December to February. Koc (2012) conducted a study at Aegean Region (hot, dry summer and mild to cool, wet winter) of Turkey and concluded that the lowest and highest LMY305 day was observed in June ($7,185 \pm 324.7$ kg) and December ($8,604 \pm 267.7$ kg), respectively and the difference between these two months was statistically significant ($p < 0.05$). Highest LMY means were observed for April ($9,948 \pm 435.3$ kg) that was 1840 kg higher ($p < 0.01$) than that of June. This type of trend was observed because of local environment. Azad *et al.*, (2007) concluded that highest milk production was in February (10.01%) and lowest in September (6.46%) and milk production gradually increased from September to February which indicated a specific milk production trend throughout the year. Lateef *et al.*, (2014) reported that

increased milk yield per animal was observed during March to June.

Standard week wise data of all 12 years were compared with respective standard of week of each week and each year and correlation and regression analysis was carried out. In all 52 meteorological standard weeks X 12 years data ($622 + 2 = 624$; last two weeks of 2014 were ignored as there were no observations) were used for correlation and regression analysis. The correlation between milk yield and MAX T was positive (0.1893) and significant. Whereas, RH1, RH2 and VP2 had negative and highly significant correlation with MY. Mylostyvyi and Chernenko (2019) concluded that DMY had positive significant ($p < 0.05$) with RH ($r = +0.4$) whereas, negative significant ($p < 0.05$) with WS ($r = -0.40$) and air temperature ($r = -0.186$). RF was also found to be negative but significantly correlated. EP and BSS had positive and highly significant correlation with average MY. There was no significant correlation among average daily MY and MIN T and VP1 but WS was significantly correlated with average weekly MY. It was calculated that MAX T, RH1, RH2, RF and VP2 had negative impact on average daily milk yield whereas; MAX T, WS, EP and BSS had positive impact on the average milk yield.

All the partial regression coefficients for independent variables were found significant except RH1, RF and VP2 but coefficient of determination (R^2) was found very low (0.1652). The result presented in table 1. This indicated that apart from the environmental factors considered in the present analysis, other factors like: housing of cows, feeding and ancillary management of cows may be played more important role in milk production.

Stepwise regression was also carried out for the selection of most important factors and for multicollinearity among the independent

variables. The result presented in table 2 indicated that final few weather parameter (MIN T, RH1, WS, EP and BSS) were included in the model. The partial regression coefficient of MIN T and BSS were found negative and highly significant whereas partial regression coefficient of RH1, WS and EP were found positive and highly significant. High EP (Evaporation rate) has been found beneficial for improving milk production of cows. Anybody (either living or non-living) on earth surface with moisture will exert effect of evaporation. Animal body also is made of approximately 75 per cent moisture. It is a known fact that higher the evaporative loss of moisture from the body, greater will be the heat loss and so the animals will be more comfortable leading to increased milk production. It is known that high temperature causes stress on the animal leading to reduction in milk production. High ambient temperature coupled with high humidity increases THI causing further increase in stress and lowered production. Das *et al.*, (2016) reported that milk production declined 14% in early lactation and 35% in mid-lactation due to heat stress. The present investigation shows that rise in minimum temperature of the area leads to highly significantly lowered production rather than high temperature. More Sunshine hours on a day leads to lowered production.

From the present study also it was also observed that the longer the Sun shines on an area, lower the production. Further, longer sunshine hours is capable of raising the minimum temperature of the environment leading to further reduction in milk production. This is the reason why production of animals reduces during summer months and increases during winter months. Similarly, partial regression coefficient of RH1 was found to be positive and significant. This means that higher morning relative humidity helps in significantly increasing milk production. Further, the present research

results suggest that wind speed improves milk production significantly. Actually, higher wind speed or a windy atmosphere helps in many ways to increase comfort of the animal thereby increasing the milk production. High wind reduces the relative humidity around the animal; more cooling effect during summer, also helps in reducing the body temperature by convective loss of heat from animal body.

The above results were indicative of important role of Min T, BSS, RH1, WS and EP in milk production of crossbred cows. The coefficient of determination (R^2) was found to be 0.1550. The final model is presented as follows:

$$MY = 7.806 - 0.171** \text{ MIN T} + 0.030** \text{ RH1} + 0.096* \text{ WS} + 0.579** \text{ EP} - 0.212**$$

Standard week wise data of all 12 years were averaged out over meteorological standard weeks and these data were further used for step wise regression analysis. The results were presented in Table 3.

From the final model it was evident that morning relative humidity and wind speed were negatively and significantly correlated. Higher morning relative humidity and more wind speed will lead to decreased milk production. Minimum temperature was positively and significantly correlated with milk yield indicating that higher minimum temperature will increase milk production. The coefficient of determination (R^2) of final model was 0.66 this indicated that the weather parameters (RH1, WS and MIN T) explained about 66% variations in weekly average milk production. The partial regression coefficient (R^2) of MIN T and RH1 were found negative and significant indicating negative impact on average milk yield whereas that of WS had positive impact on average milk yield (Table 4).

Table.1 Average daily milk production (kg/milking animal) of crossbred cows of recorded during 12 years period

Month/Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Overall
Jan	5.32 ^a	5.79 ^a	7.28 ^{abc}	9.23 ^{cde}	9.89 ^e	9.04 ^{bc}	7.20 ^{ab}	10.15 ^{efg}	11.41 ^{ef}	9.88 ^{bc}	11.45 ^f	12.35 ^h	9.08 ^{bcd}
	± 0.08	± 0.10	± 0.09	± 0.16	± 0.15	± 0.14	± 0.21	± 0.18	± 0.18	± 0.18	± 0.78	± 0.86	± 0.65
Feb	5.31 ^a	6.65 ^{abc}	8.26 ^c	10.03 ^e	9.85 ^e	8.67 ^{abc}	6.85 ^a	11.24 ^g	11.80 ^f	11.44 ^d	11.64 ^f	14.36 ⁱ	9.68 ^{de}
	± 0.27	± 0.20	± 0.1	± 0.16	± 0.14	± 0.13	± 0.23	± 0.16	± 0.14	± 0.20	± 0.27	± 0.80	± 0.76
Mar	13.83 ^g	8.78 ^{de}	8.31 ^c	10.04 ^e	9.62 ^{de}	8.21 ^{ab}	7.35 ^{abc}	11.19 ^g	10.90 ^{def}	11.63 ^d	10.83 ^{ef}	11.21 ^{fgh}	10.15 ^d
	± 0.55	± 0.30	± 0.09	± 0.14	± 0.13	± 0.10	± 0.24	± 0.16	± 0.14	± 0.17	± 0.25	± 0.64	± 0.52
Apr	11.24 ^f	10.25 ^{fg}	7.66 ^{abc}	9.53 ^{de}	9.44 ^{cde}	8.13 ^{ab}	8.76 ^d	10.45 ^{fg}	10.68 ^{cdef}	11.11 ^{cd}	9.54 ^{bcd}	10.62 ^{efg}	9.78 ^{cd}
	± 0.43	± 0.15	± 0.10	± 0.14	± 0.13	± 0.13	± 0.23	± 0.17	± 0.12	± 0.21	± 0.24	± 0.42	± 0.33
May	10.14 ^{ef}	9.97 ^{efg}	7.96 ^{bc}	8.73 ^{bcd}	8.11 ^{ab}	7.72 ^a	8.41 ^{bcd}	9.74 ^{def}	11.37 ^{ef}	11.53 ^d	8.81 ^{ab}	10.10 ^{efg}	9.38 ^{de}
	± 0.17	± 0.14	± 0.09	± 0.12	± 0.11	± 0.11	± 0.22	± 0.13	± 0.15	± 0.18	± 0.20	± 0.37	± 0.37
Jun	9.22 ^{de}	10.48 ^g	7.43 ^{abc}	8.12 ^{bc}	8.37 ^{abcd}	8.70 ^{abc}	8.62 ^{cd}	8.50 ^{bcd}	10.45 ^{bcd}	11.00 ^{cd}	8.16 ^a	10.02 ^{ef}	9.09 ^{bcd}
	± 0.13	± 0.16	± 0.09	± 0.10	± 0.11	± 0.16	± 0.22	± 0.13	± 0.13	± 0.18	± 0.20	± 0.31	± 0.33
Jul	7.99 ^{cd}	9.08 ^{ef}	7.72 ^{abc}	7.67 ^{ab}	8.19 ^{abc}	8.18 ^{ab}	8.60 ^{cd}	8.20 ^{bc}	9.36 ^{ab}	10.12 ^{bc}	9.22 ^{abc}	9.67 ^{de}	8.67 ^{abc}
	± 0.12	± 0.15	± 0.08	± 0.10	± 0.11	± 0.18	± 0.21	± 0.12	± 0.13	± 0.18	± 0.22	± 0.23	± 0.23
Aug	6.62 ^b	7.73 ^{cd}	7.53 ^{abc}	6.79 ^a	7.32 ^a	7.51 ^a	8.10 ^{abcd}	7.62 ^{ab}	8.45 ^a	10.73 ^{cd}	8.97 ^{ab}	8.61 ^d	8.00 ^{ab}
	± 0.09	± 0.11	± 0.08	± 0.11	± 0.11	± 0.17	± 0.13	± 0.15	± 0.12	± 0.18	± 0.24	± 0.18	± 0.32
Sep	6.76 ^{bc}	7.38 ^{bc}	6.82 ^{ab}	7.65 ^{ab}	7.31 ^a	7.59 ^a	6.97 ^a	6.70 ^a	8.58 ^a	10.11 ^{bc}	9.99 ^{bcd}	6.89 ^c	7.73 ^a
	± 0.09	± 0.11	± 0.09	± 0.15	± 0.11	± 0.15	± 0.13	± 0.13	± 0.14	± 0.17	± 0.28	± 0.15	± 0.35
Oct	5.72 ^{ab}	6.33 ^{ab}	6.62 ^a	7.64 ^{ab}	7.50 ^a	8.00 ^{ab}	7.09 ^a	6.82 ^a	9.60 ^{abcd}	9.18 ^{ab}	10.56 ^{def}	5.61 ^a	7.56 ^a
	± 0.08	± 0.09	± 0.09	± 0.16	± 0.15	± 0.16	± 0.15	± 0.14	± 0.16	± 0.16	± 0.24	± 0.17	± 0.45
Nov	5.08 ^a	5.66 ^a	6.52 ^a	9.04 ^{cde}	8.85 ^{bcd}	8.78 ^{abc}	7.58 ^{abcd}	7.59 ^{ab}	9.58 ^{abc}	8.25 ^a	10.46 ^{cdef}	5.92 ^{bc}	7.78 ^a
	± 0.10	± 0.10	± 0.10	± 0.16	± 0.29	± 0.21	± 0.24	± 0.18	± 0.19	± 0.15	± 0.21	± 0.21	± 0.49
Dec	4.62 ^a	5.77 ^a	7.11 ^{abc}	8.80 ^{bcd}	9.53 ^{de}	9.54 ^c	7.10 ^a	9.04 ^{cde}	9.96 ^{bcd}	9.13 ^{ab}	10.73 ^{def}	4.39 ^a	7.98 ^{bc}
	± 0.11	± 0.11	± 0.09	± 0.15	± 0.17	± 0.16	± 0.22	± 0.18	± 0.19	± 0.16	± 0.22	± 0.37	± 0.62
Overall	7.66	7.82	7.44	8.60	8.67	8.34	7.72	8.94	10.18	10.34	10.03	9.15	8.74
	± 0.84	± 0.53	± 0.17	± 0.30	± 0.29	± 0.18	± 0.21	± 0.47	± 0.32	± 0.31	± 0.32	± 0.86	± 0.26

Table.2 Regression coefficients for weekly and yearly average data of milk yield and different climatic factors

Variable	Parameter Estimate	Standard Error	t Value	Pr> t
MY	5.99636	1.45033	4.13	<.0001
MAX T	0.09916	0.05263	1.88	0.0600
MIN T	-0.20020	0.06284	-3.19	0.0015
RH ₁	0.01259	0.01520	0.83	0.4079
RH ₂	0.04112	0.01934	2.13	0.0339
WS	0.17475	0.05572	3.14	0.0018
EP	0.44756	0.08978	4.98	<.0001
RF	-0.00071	0.00169	-0.42	0.6743
BSS	-0.16768	0.06092	-2.75	0.0061
VP ₁	0.06526	0.07714	0.85	0.3979
VP ₂	-0.15100	0.07571	-1.99	0.0465
R² = 0.1652				

Table.3 Stepwise regression analyses for weekly and yearly average of milk yield and different climatic factors

Variable	Partial R ²	Model R ²	C(p)	F value	Pr> F
EP	0.0892	0.0892	48.6472	60.70	<.0001**
MIN T	0.0194	0.1086	36.4119	13.51	0.0003**
BSS	0.0305	0.1391	16.0717	21.91	<.0001**
RH ₁	0.0075	0.1466	12.5996	5.41	0.0204**
WS	0.0084	0.1550	8.4644	6.11	0.0137**
R²=0.1550					

Table.4 Stepwise regression analysis for weekly average of milk yield and different climatic factors

Variable	Parameter Estimate	Partial R ²	Model R ²	C(p)	F Value	Pr > F
RH ₁	-0.07260	0.5580	0.5580	13.4891	63.11	<.0001*
WS	-0.11841	0.0488	0.6068	8.6996	6.08	0.0172*
MIN T	0.28066	0.0482	0.6585	3.9932	6.71	0.0127*
R²=0.6550						

Sunshine hours and wind velocity showed positive significant and MAX T, MIN T, RH1, RH2, THI showed negative non-significant association with lactation milk yield was concluded by Thorat *et al.*, (2010). Das (2012) analyzed multiple regressions between different micro environmental parameters and milk yield of cow and concluded that air temperature, effective temperature had significant ($P < 0.01$) effect on average daily milk yield/ cow (Kg) and average weekly milk yield / cow (Kg). MAX T, BSS and maximum THI exhibited negative and significant regression result with lactation milk yield and all the considered climatic variables (Max T, Min T, Max Hum, Min Hum, BSH, WS, Max THI, Min THI) accounted for 28 % direct variation on lactation milk yield as verified by the value of coefficient of determination (R^2) was reported by Zewdu *et al.*, (2014).

In conclusion, the overall average DMY of cross bred cows during 12 years period (2003-2014) was 8.73 ± 0.26 kg. Morning relative humidity, wind speed and minimum temperature were responsible for 66% variations on milk production.

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