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EFFECT OF ENVIRONMENTAL FACTORS ON LACTATION YIELD AND LACTATION LENGTH OF HOLDEO CROSSBRED CATTLE

KEYWORDS: lactation milk yield, lactation length, environmental variables, THI, heat stress

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ABSTRACT *The study was undertaken to evaluate the effect of different macro climatic variables on lactation length and lactation milk yield of Holdeo (Holstein Friesian x Deoni) crossbred cattle. Milk data of 145 Holdeo crossbred cows with 619 of lactation records and the meteorological data over a period of 15 years (1995-2003) were obtained from Cattle Cross Breeding Project, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani and University Meteorological Observatory, respectively. It was observed that lactation milk yield and lactation length was highest (1136.56 + 21.04 and 295..29 + 5.51) among the cows calved during winter season as compared to rainy (1073.29 + 79.92, 277.04 + 5.3) and summer season (1096.71 + 86.95, 274.53 + 7.29). All the climatic variables considered in the study accounted for 68 %, 56 % and 46 % direct variation on lactation milk yield and 57 %, 53 % and 48 % direct variation on lactation length in rainy, winter and summer season, respectively, as verified by the value of coefficient of determination (R2). This research indicates that crossbred cows were sensitive to seasonal changes on their lactation length and lactation milk yield. High temperature with high humidity had a detrimental effect on lactation yield and lactation length of Holdeo crossbreds. The optimum ranges of temperature; humidity and THI for better performance of crossbred in subtropical region of India were found to be 19-26 oC, 52-66 per cent and 65-68 per cent, respectively. The meteorological observation during the period of study confirmed that there was high value of THI in seven months (March- September) in a year, which suggests that most crossbred cows are exposed to negative effects of heat stress in this region and demanding additional productive strategies like improving environment, management and comfort level of cows for maintaining their lactation performance.*

INTRODUCTION

Climate change, particularly global warming, may strongly affect production performance of farm animals worldwide. Among the environmental variables affecting animals, heat stress seems to be one of the intriguing factors making animal production challenging in many geographical locations in the world (Koubkova et al. 2002). Climate change scenario constructed for India revealed that temperature rise of about or more than 4˚C is likely to increase uncomfortable days (THI>80) from existing 40 days (10.9%) to 104 days (28.5%). This change in THI has a negative impact on the livestock production both directly and indirectly.

One of the direct impacts of climate change on livestock is on the milk yield. A thermal environment is a major factor that can negatively affect milk production in dairy cows, especially in animals of high genetic merit. The extent of milk yield decline observed in heat-stressed cows is dependent on several factors that interact with high air temperature. The milk yield losses seem positively related with milk yield of cows. The increase in milk yield increases sensitivity of cattle to thermal stress and reduces the threshold temperature at which milk losses occur (Berman, 2005).

Crossbred animals play a major role in Indian dairy industry and contributing about 43 per cent share of cow milk. These crossbred cattle blood are more susceptible to environmental changes. Cattle Cross Breeding Project, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra located in subtropical region of India has developed a crossbred cattle named Holdeo (Holstein Friesian x Deoni). The information on the effect of environmental variables on lactation milk yield and lactation length of this crossbred cattle is lacking. Hence this research is planned to measure variation in lactation performance (lactation yield and lactation length) due to environmental factors in Holdeo (HF x Deoni) crossbred cattle.

MATERIALS AND METHODS

Study area and duration

This study was conducted at Cattle Cross Breeding Project (CCBP), VNMKV, Parbhani, Maharashtra, India, which is located at an 19 °16' North latitude and 76°74' East latitude and 409 m above mean sea level. The climate of the region is subtropical one and the region comes under assured rainfall zone with an average annual rainfall of 885 mm mostly received in about 70 days during June to September. On seasonal basis, it oscillates from humid to sub humid in monsoon, sub humid to semi-arid during post-monsoon and hot and dry in summer. 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.

For this study, data of 145 Holdeo crossbred cows (Hol-

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stein Friesian x Deoni) during the period of 1995-2009 with 619 records of lactation and cows having at least three offspring were selected for analysis. Meteorological data (1995-2009) were obtained from the University meteorological observatory station. The complete year was divided into 3 seasons as rainy (June to September), winter (October to January) and summer (February to May).

Management of experimental animals

The management details at this farm were somewhat identical with variation due to reason beyond control. The daily routine for milch animals started at 4.30 a m. The animals were milked by about 5.30 am to 6.30 am after feeding concentrate mixture. The udders were washed with water and cleaned dry with cloth before milking. The animals were allowed to graze from 8.30 am to 2.30 pm daily. The animals were then tied and stall fed required quantities of dry kadbi and seasonal greens. They were again cleaned at 3.30 pm and fed concentrates and milked subsequently at 4.30 pm. All calves were separated from their dam at birth and weaned thereafter. 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 diet and transferred to the milking herd afterwards.

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 Quarter and Haemorrhagic Septicaemia. The milking cows were washed and groomed regularly and fed individually. The teaser bull was used for regular heat detection. Upon heat detection, cows were mated naturally to a bull. From conception upto seven months of pregnancy, cows were grazed on natural pasture after which they were kept indoor and offered roughage and concentrate feed.

Determination of temperature humidity index (THI)

THI is a useful and easy way to assess the risk of heat stress. THI is calculated according to National Research Council (1971) as follows:

$$THI = 0.72 (dbt\ ^0C + wbt\ ^0C) + 40.6$$

Where, dbt ^{0}C = dry bulb temperature (^{0}C) ; wbt ^{0}C = wet bulb temperature (^{0}C)

Determined THI values were used to identify heat stress and to examine the monthly variation of THI.

Statistical analysis

To investigate the effect of environmental variables on lactation length, lactation milk yield and peak yield, the data were analysed by using correlation and multiple regression model. The main environmental variables were also compiled as monthly minimum and maximum temperature, monthly minimum and maximum relative humidity, monthly wind speed (km/hr) and monthly sunshine (hr) as well as THI.

Data were analysed 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 length, lactation milk yield and peak milk yield.

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

where, Y is dependent variable; x is independent variables; a is constant; b is coefficient of x and uij is error term.

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

To determine the role various environmental factors in the variation of lactation length, lactation milk yield and peak yield, stepwise regression was undertaken based on the contribution of different environmental variables. Basically, regression helps to estimate the functional relationship between the independent and dependent variables.

RESULTS AND DISCUSSION

Environmental variables during the period of study:

The average monthly environmental variables viz., ambient temperature, relative humidity, sunshine hours, wind speed and temperature humidity index are presented in Fig.1 and lactation yield and lactation length are presented in Fig 2 during the period of study (1985-2009). The environmental condition observed in the table clearly indicate that the study area is under humid to sub humid in monsoon, sub humid to semi-arid during winter and hot and dry in summer. The lactation yield of Holdeo crossbred cattle ranged from 972.20 lit (1999) to1655.28 lit (2008) with average lactation yield of 1266.40 $\pm$ 46.69 lit, whereas lactation length ranged from 263.96 days (1997) to 304.18 days (2001) with average lactation length of 287.19 $\pm$ 2.75 days.

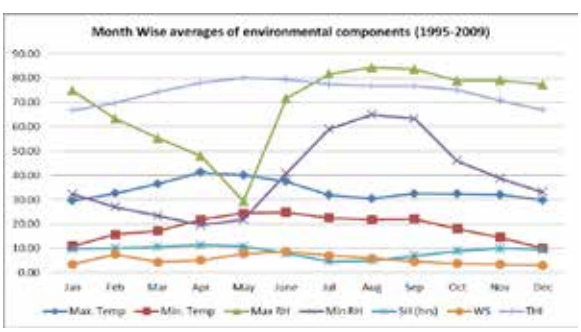

Fig 1. Month wise averages of Environmental Components (1995-2009)

Fig 2: Lactation length (days) and Milk yield (kg) of Holdeo crossbred cows (1995-2009)

Effect of environmental variables on lactation length

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and lactation yield of Holdeo Crossbred cattle in rainy season:

Average lactation yield and lactation length of Holdeo cattle was recorded as 1073.30 ± 79.92 lit and 277.04 ± 5.3 days in rainy season, respectively. It is evident from Table 1 that different climatic factors not established significant association with lactation length. All the correlation coefficient values except minimum humidity (-0.467) and wind speed (-0.256) were negative and non significant, while THI (0.313) was positive but non-significant relation with lactation length. The values were moderate degree being 0.664 to 0.789 and 0.504 to -0.467 in Holdeo crossbreds. This trend indicates the increase of lactation length with decrease in minimum temperature and increase in humidity.

Table 1. Correlation and Regression coefficients for lactation length and lactation milk yield in Holdeo cross bred cattle during rainy season

Variables	Mean ± SE	LL				LMY			
		r	b	SE of (b)	t value	r	b	SE of (b)	t value
Max Temp (°C)	33.06 ± 0.20	0.664**	3.94	0.97	4.04**	0.881**	43.68	13.41	3.25**
Min Temp (°C)	22.91 ± 0.20	0.789**	33.73	9.63	3.50**	0.543*	90.08	23.25	4.26**
Max Hum (%)	81.30 ± 0.66	0.504*	21.41	6.96	3.07**	0.610**	-1.60	95.86	-0.016
Min Hum (%)	57.58 ± 1.17	-0.467^{NS}	-8.68	3.26	-2.58	-0.531 ^{NS}	-33.32	46.25	-0.72
SH (hrs)	06.12 ± 0.16	0.505*	-0.56	10.03	-0.56	0.648**	-21.84	13.80	-1.58
WS (km/hr)	08.96 ± 0.18	-0.256 ^{NS}	-18.62	9.94	-1.87	0.728**	85.20	13.68	6.22**
THI	68.89 ± 4.16	0.313 ^{NS}	-0.47	0.44	1.07	0.284 ^{NS}	6.37	2.13	2.98*
		R^2 = 0.686 F value = 2.18				R^2 = 0.573 F value = 0.89			

*** Significant at 0.05 per cent** **** Significant at 0.01 per cent**

r = Correlation coefficient, b = Estimated regression coefficient, max Temp (oC) = Maximum temperature, Min Temp (oC) = Minimum temperature, Max Hum = Maximum humidity, Min Hum = Minimum humidity, SH = Sunshine hours, WS = Wind speed, THI= Temperature humidity index LMY = Lactation milk yield LL = Lactation length.

With regards to lactation yield it was observed that correlation coefficient values were positively significant except minimum humidity, which shows negative significant relation with milk yield for Holdeo crossbreds.

All the considered environmental variables accounted for 68.60 per cent and 57.30 per cent variation in lactation milk yield and lactation length, respectively. The value of coefficient of determination (R^2) value did not reach the level of significance. This shows that lactation yield and lactation length could not be influenced consistently by climatic factors. The lactation milk yield is increased with lactation length in present study. A strong regression coefficient has been noted between lactation length and lactation yield. Shinde and Taneja (1986) also observed that regression coefficient of lactation length on milk yield was highly significant.

Effect of environmental variables on lactation yield and lactation length of Holdeo Crossbred cattle in winter season:

Generally winter climate condition favours the milk production in animal due to pleasant climate and availability of quality fodder. Average lactation milk yield and lactation length was recorded as 1136.56 ± 21.04 lit and 295.29 ±5.51 days in winter season, respectively. These indicated that lactation milk yield in Holdeo crossbred cattle was more in winter season than rainy and summer season, confirming the general consideration of suitability of crossbred cattle under cold climate. It is evident from Table 2 that environmental factors except minimum temperature and maximum temperature establish significant positive association with lactation length and lactation yield. It can be accessed from the table that milk yield is increased with decrease in maximum temperature as value being from 0.161 to - 0.326; whereas relative humidity level showed that with decrease in humidity level lactation yield is increased up to certain level. The degree of 'r' value indicates more favourable effect of winter climate on performance of Holdeo crossbred, supporting the necessity of cold climate for better performance of crossbreds. Multiple regression values indicate that one unit increase in ambient temperature and wind velocity decrease milk yield by -7.24 and 2.19 units, respectively. On the other hand, maximum and minimum temperature had influenced negatively. The one unit increase in minimum ambient temperature reduces lactation length by -1.95 days.

Table 2. Correlation and Regression coefficient for lactation length and lactation milk yield in Holdeo Crossbred cattle during winter season

Variables	Mean ± SE	LL				LMY			
		r	b	SE of (b)	t value	r	b	SE of (b)	t value
Max Temp (°C)	31.04 ± 0.24	-0.152 ^{NS}	-1.95	69.74	-0.028	0.161 ^{NS}	-7.24	7.14	-1.01
Min Temp (°C)	13.36 ± 0.33	-0.301 ^{NS}	-74.6	48.14	-1.55	-0.326 ^{NS}	-8.57	4.92	-1.73*
Max Hum (%)	77.20 ± 0.81	0.539*	5.7	1.97	2.90**	0.783**	5.65	2.02	2.79**
Min Hum (%)	36.98 ± 0.83	0.462*	10.8	1.98	5.48**	0.594*	6.17	2.03	3.04**
SH (hrs)	09.57 ± 0.10	0.729**	127.5	33.74	3.77**	0.697**	7.26	2.55	2.84**
WS (km/hr)	03.28 ± 0.11	0.842**	44.59	10.99	4.05**	-0.131 ^{NS}	2.19	11.2	1.95
THI	70.00 ± 0.30	0.271 ^{NS}	19.61	38.14	0.51	0.194 ^{NS}	4.07	1.90	2.14*
LMY =1136.56 ± 21.04 LL = 295.29 ±5.51		R^2 = 0.53 F value = 0.755				R^2 = 0.56 F value = 0.85			

*** Significant at 0.05 per cent** **** Significant at 0.01 per cent**

r = Correlation coefficient, b = Estimated regression coefficient, max Temp (oC) = Maximum temperature, Min Temp (oC) = Minimum temperature, Max Hum = Maximum humidity, Min Hum = Minimum humidity, SH = Sunshine hours, WS = Wind speed, THI= Temperature humidity index LMY = Lactation milk yield LL = Lactation length.

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All the considered environmental variables accounted for 56 per cent and 53 per cent variation in lactation milk yield and lactation length, respectively. However R^2 value does not exceed the level of significance for lactation yield indicating influence of environmental factors on lactation yield. Bajwa et al. (2004) observed that year and season of calving both significantly ($P < 0.01$) affected milk yield and lactation length.

Effect of environmental variables on lactation yield and lactation length of Holdeo Crossbred cattle in summer season:

Generally summer climate condition at location of study was hot dry. Average lactation milk yield and lactation length was recorded as 1096.70 ± 186.59 lit and 274.53±7.29 days in summer season, respectively. It is interesting to note that the maximum ambient temperature established positive significant association with lactation yield and lactation length in summer season. Correlation coefficient values for THI were non-significant. Ambient temperature alone has contributed more variation in milk yield and lactation length as 'r' value ranges between 0.507 to -0.124 for lactation yield and 0.6625 to -0.34 for lactation length. However the humidity level has strong positive role in milk production variation in Holdeo crossbreds, indicating decrease in milk yield with increase in humidity level. The results of Kulkarni *et al*. (1996) are supporting the present trend of effect of humidity on lactation yield and lactation length.

Table 3. Correlation and Regression coefficient for lactation length and lactation milk yield in Holdeo crossbred cattle during summer season

Variables	Mean ± SE	LL				LMY			
		r	b	SE of (b)	t value	r	b	SE of (b)	t value
Max Temp (°C)	37.92 ± 0.34	0.626**	44.70	15.62	7.02**	0.507*	3.34	1.64	2.54**
Min Temp (°C)	22.52 ± 0.31	-0.345 NS	41.14	132.34	2.86*	-0.124 NS	17.44	5.38	3.24***
Max Hum (%)	53.60 ± 0.77	-0.567*	-0.086	31.23	-0.002	0.657**	3.83	1.26	3.03**
Min Hum (%)	25.86 ± 0.35	0.763**	-20.42	80.73	-0.25	0.495 NS	6.33	8.43	0.75*
SH (hrs)	11.04 ± 0.10	0.212 NS	12.26	3.00	4.21**	0.306*	-16.90	20.94	-0.80
WS (km/hr)	06.23 ± 0.10	0.191 NS	140.5	228.88	0.61	0.110 NS	-5.47	23.90	-0.22
THI	75.87 ± 0.12	-0.509NS	-142.6	170.37	-0.83	-0.229 NS	-18.22	17.79	-1.02
LMY =1096.70 ±186.59 LL = 274.53±7.29		R^2 = 0.487 F value = 0.632				R^2 = 0.465 F value = 0.575			

* Significant at 0.05 per cent ** Significant at 0.01 per cent

r = Correlation coefficient, b = Estimated regression coefficient, max Temp (oC) = Maximum temperature, Min Temp (oC) = Minimum temperature, Max Hum = Maximum humidity, Min Hum = Minimum humidity, SH = Sunshine hours, WS = Wind speed, THI= Temperature humidity index LMY = Lactation milk yield LL = Lactation length.

From Table 3, it is seen that all the considered environmental variables accounted for 48.70 per cent and 46.50 per cent variation in lactation length and lactation milk yield, respectively. Moreover R^2 value was significant at 5 per cent level indicating consistency in effect of climatic factor on lactation length and lactation yield. The regression coefficient attributed to maximum temperature and humidity level, it was significant at 1 per cent level. This trend calls upon the need of providing thermal comfort to crossbred through proper orientation ans ventilation arrangement in barn. In agreement with Afzal *et al*. (2007) and Hyder et al. (2007) observed that buffaloes calving in spring showed highest and those calving in summer showed lowest milk yield.

CONCLUSION

This research indicates that crossbred cows were sensitive to seasonal changes on their lactation length, lactation milk yield and peak yield. High temperature with high humidity had a detrimental effect on lactation length and lactation milk yield. The optimum range of temperature, humidity and THI for better performance of crossbred in subtropical region of India was found to be 19-26 °C, 52-66 per cent and 65-68 per cent, respectively. The meteorological observation during the period of study confirmed that there was high value of THI in seven months (March-September) in a year, which suggests that most crossbred cows are exposed to negative effects of heat stress in this region and demanding additional productive strategies like improving micro environment and comfort level of cows for maintaining their lactation performance.

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