International Journal of GEOMATE, March, 2020, Vol.18, Issue 67, pp. 108-113
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2020.67.5807
Special Issue on Science, Engineering and Environment

EFFECTS OF CLIMATE CHANGE ON MILK YIELD AND MILK COMPOSITION IN THAI CROSSBRED HOLSTEIN COWS

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ABSTRACT: The purpose of this research was to study effects of climate changes on milk yield and milk composition of Holstein crossbred **.** This study uses data recording total milk production per farm each day and milk composition (from 2013–2017): fat percentage (% Fat), protein percentage (% Pro), solid not fat percentage (% SNF) and total solid percentage (% TS) from 79 farmers in Mahasarakham Province, Thailand**.** The temperature and humidity data were obtained from records of meteorological center. Using temperature and relative humidity for calculate temperature humidity index (THI). The effects of THI on milk yield and milk composition were assessed by procedure REG using SAS. The study indicated that, the weather was hot and humid. The temperature ranged from 20.88 – 33.01 ° C. and average humidity was 72.59%. The highest THI (82.07) was in May. The relationship between THI and milk yield was negatively related. The slope value was -0.099, it meaning that when the THI value increased by 1 unit the milk yield decreased by 0.099 kg / cow / day. The THI group for effect of THI on milk yield and milk composition was set 4 groups (THI 1 = THI ≤70, THI 2 = 74 ≤THI <70, THI 3 = 78 ≤THI <74, THI 4 = THI> 78). The highest THI effect on low milk yield. In contrast, low THI (THI 1 and THI 2) effect on high milk yields. The climate change, temperature and humidity increase effects on milk production of dairy cows to decrease.

Keywords: Climate Change, Milk Yield, Milk Composition

1. INTRODUCTION

Thailand has a tropical climate with high ambient temperatures and relative humidity. Average temperature is 35.0–39.9 °C and average relative humidity is 72–74 % [1]. Dairy cows that have experienced high temperature and humidity for a long time will reduce milk production and milk quality. Heat stress could be significant reason reduced dairy production in many countries. The exposure of lactating dairy cows to high ambient temperatures, high relative humidity and solar radiation for extended periods decreases their ability to disperse heat. Under heat stress conditions, lactating dairy cows exhibit several physiological responses including a voluntary reduction of feed intake, an increase in maintenance requirements, decrease in milk yield, and milk composition [2]. At the same time, lactating dairy cows create a large quantity of metabolic heat. So, accumulated and produced heat joined with decreased cooling capability induced by environmental conditions, causes heat stress in the animals. Finally, heat stress induces increase of body temperature. In addition, heat stress also effects the health of dairy cows because they are at high temperature and humidity and will not be able to maintain balance of the body due to heat stress.

The Temperature Humidity Index (THI) is widely used in hot areas all over the world to assess the impact of heat stress on dairy cows [3]. The THI is expressed as a single value representing the combined effects of air temperature and humidity, which is commonly used to evaluate the degree of heat stress in dairy cattle. According to [4] the effect of heat stress on Thai Holstein crossbreds increased greatly with parity and was especially large after a THI of 80 for cows with a high percentage of Holstein genetics (HS ≥ 93.7%). Moreover, [5] showed that heat stress conditions indicated by mean daily values of THI >72 were determined during spring and summer season**.** The daily THI at which milk production started to decline for milk yield and milk composition ranged from 65 to 76 [6]. When THI reaches 72, milk production as well as feed intake begins to decrease. Milk production during the summer season will be lower than in the winter season by about 10-40% [5].

In addition, heat stress could also cause changes in milk composition, milk somatic cell counts (SCC) and mastitis frequencies. A study comparing milk protein fractions in milk collected from cows in spring and summer, found that the α-casein and β-casein in serum decreased in the summer season [7].

Some studies have estimated the genetic components for both milk yield and reproduction traits under heat stress. The results showed an unfavorable genetic relationship between THI and productive and reproductive traits. Those findings indicate that the intensive selection (especially for milk production traits) applied to dairy cows might have led to higher heat stress susceptibility in these animals [8]. Therefore, the objective of this research was to study the effects of climate changes on milk yield and milk composition of Thai crossbred Holstein cows in Thailand.

2. MATERIALS AND METHODS

2.1 Data and Data Preparation

This study uses data to record total milk production per farm each day and milk composition data: fat percentage (% Fat), protein percentage (% Pro), solid not fat percentage (% SNF) and total solid percentage (% TS) from farms of the Khok Kao Dairy Cooperative Limited (79 farms) in Mahasarakham Province, Northeast of Thailand. Data was collected from January 2013 until December 2017. Thai crossbred Holstein cows were housed in a covered tie stall barn with straw bedding. Metal roofs covered the stalls. All the dairy farms were managed and maintained in the same way and all dairy cows were raised in an open house. The diet was mixed and fed as TMR. The ratio of concentrate to forage was 4:6 based on DM content. Cows were milked 2 times per day at 06.00 a.m. and 17.00 p.m. using a milking machine.

The temperature and relative humidity data (from January 2013 – December 2017) obtained from the records of the meteorological center closest to each dairy farm based on postal code. The weather information included daily temperature and relative humidity recorded every 3 h, which were used to calculate the temperature humidity index (THI) in Microsoft Excel by using the equation bellow [9].

$$THI = (0.8*Ta) + (RH/100)*(Ta-14.4) + 46.4$$

Where, Ta is temperature in °C and RH is relative humidity as a percentage.

The THI values were divided into 4 groups as follows: - THI 1 is THI ≤ 70, THI 2 is $74 \leq THI < 70$, THI 3 is $78 \leq THI < 74$ and THI 4 is THI > 78. The highest THI values were THI 4 and the lowest THI value were THI 1. These THI groups (group 1–4) were used for estimating the effects of THI on milk production and milk composition on Thai Holstein crossbred cattle.

2.2 Statistical Analysis

The means of milk yield and milk composition on Thai Holstein crossbred were analyzed by PROC MEANS using SAS 1998. [13]

The relationships between THI and milk yield and milk composition on Thai Holstein crossbred assessed by the procedure REG in SAS version 8.02 [10]. The differences were considered to be significant at $P < 0.05$, unless otherwise indicated.

3. RESULTS AND DISCUSSION

The results effects of climate change on milk yield and milk composition in Thai crossbred Holstein cows are show as follows.

3.1 Climatic Condition in Mahasarakham Province of Thailand

Mean, standard division (SD), minimum (Min.) and maximum (MAX.) of milk/day, milk composition: fat percentage (% Fat), protein percentage (% Pro), solid not fat percentage (% SNF) and total solid percentage (% TS), temperature (Ta), relative humidity (RH) and calculated THI by the experimental period are shown in Table 1. The result showed climatic conditions in Mahasarakham Province, Thailand could be characterized as hot and humid with temperature between 23.57 – 30.85 °C and mean relative humidity of 72.59 % (Table 1). The highest temperatures occurred between April–May (30.85 – 30.44°C) and lowest in December (23.57°C).

The temperature and relative humidity (THI) data between January, 2013 - December, 2017 calculate from equation 1. The THI values were shown in Fig. 1. The THI was highest in May (82.07), associated with the summer season and was lowest in December (71.66) in the winter season. The winter period was characterized by a lack of heat stress conditions; mean minimum Ta and RH were 23.57 °C and 63.21%, respectively. In contrast to the summer period was characterized by heat stress conditions; mean maximum Ta and RH were 30.85 °C and 82.73%, respectively. Average THI exceeded the 78.34 critical points, for this period indicating that cows were exposed to heat stress during the summer.

The average of milk/ day was 12.69 kg. The milk composition had average values of %fat, %protein, %SNF, and %TS of 3.47% 2.90% 8.33% and 11.79%, respectively. The research of [11] reported % fat and %protein from their study as 3.91% and 3.10% which is higher than this study. Milk production from this study was lower because it was the milk yield from small dairy farms and of poor farm management. Moreover, THI from this study corresponded with values of 72 - 80 reported by [12] and from Mahasarakham province, with an average higher than the critical point at THI 75. [4] reported that, for third parity, test-day milk yield started to decline above a THI of 74 for cows with ≥87.5% Holstein genetics and declined more rapidly above a THI of 82.

Table 1 Data structure of milk production and milk composition in Thai x Holstein crossbreeds

Traits	N	Mean	SD.	Min.	Max.
milk/day ; kg	3438	12.69	5.03	5.27	37.07
fat; %	2610	3.47	0.59	1.65	10.72
pro; %	2682	2.90	0.45	2.13	22.87
SNF; %	2621	8.33	0.85	2.69	13.82
TS; %	2609	11.79	1.10	3.92	18.77
Ta; °C	3746	27.79	2.45	23.57	30.85
RH; %	3746	72.59	6.97	63.21	82.73
THI	3746	78.34	3.70	71.66	82.07

Note: N is the number of data; SD. is standard division; Min. is Minimum; Max. is Maximum

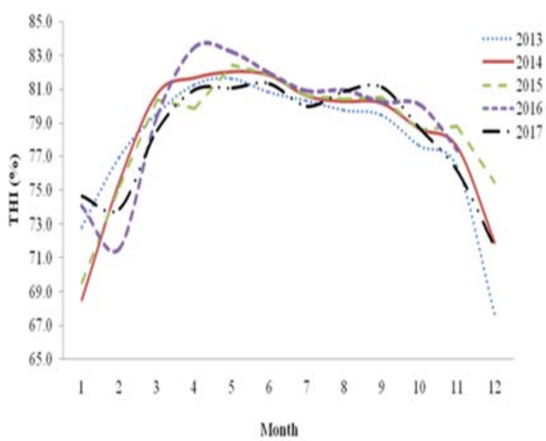

Fig. 1 The average THI in each month (January 2013 – December 2017) of the Northeast of Thailand

3.2 The Relationship between THI and Milk and Milk Composition

Fig. 2 and Fig.3 shows the relationship between THI and milk yield and milk compositions in Thai crossbred Holstein cows. The negative slope of the regression line indicates that milk yield decreases as THI increases (Fig. 2). The equation for predicting milk is Milk production (kg/cow/day) = -0.795(X) + 81.82 (R^2 = 0.361). However, when the THI value is increased, the % fat value increases (Fig. 3). This may be because the % fat value has a negative genetic correlation with the milk yield (data not showed). Heat stress is one of the major factors that can negatively affect milk production, reproduction, and the health of dairy cows. The THI had the greatest effect on milk yield. Season, especially the high-temperature season, significantly affected milk production and milk composition. The Wood equation was appropriate for a quantitative description of seasonal variation in milk composition in individual cows or herds. The changing patterns of milk composition and related indices in different months provide scientific evidence to reasonably improve the feeding management and nutritional supplementation of Chinese Holstein cows [11].

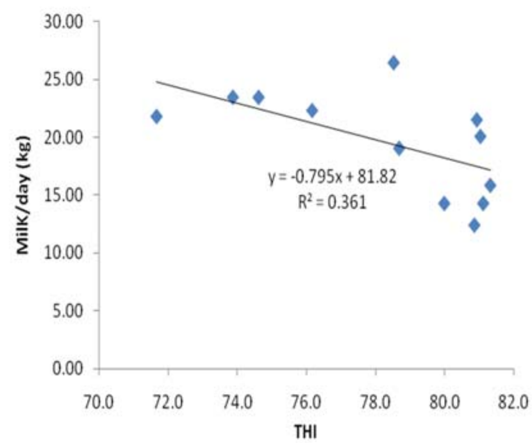

Fig.2 The relationship between THI and milk/day (kg) in Thai crossbred Holstein cows

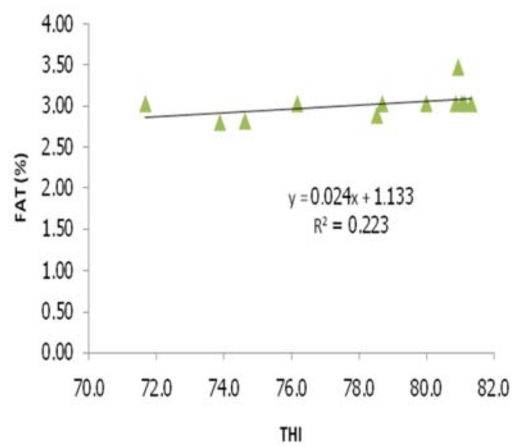

Fig.3 The relationship between THI and % fat (%) in Thai crossbred Holstein cows

3.3 Rate of Decline of Milk and Milk Composition

The Slope (Table 2) is rate of decline on milk yield and milk compositions. This regression indicates that, in general, for each point increase in the THI value, there was a decrease in milk yield of 0.099 kg/ cow/ day (slope -0.099). A large part of the variation in milk yield could therefore be attributed to heat stress. Hot weather conditions are associated with reductions in dairy cow feed intake and milk yield [13]. In addition, it can be seen that when the THI value is increased, the % protein value will be reduced 0.004%. The results of this study show that dairy cows suffer from heat stress (higher THI), resulting in reduced milk yield. However, the increased THI values effected an increase in % fat, % SNF and % TS values but did not affect % protein (Table 2). Because of the genetic correlation between the milk yield and milk composition value in milk (%fat, %SNF and %TS) is negative genetic correlation. Approximated genetic correlations between fat and milk production traits in first parity of Canadian Holsteins [14]. The results showed that average daily genetic correlations were negative for the fatty acid groups with milk production (−0.62 to −0.59) and with protein yield (−0.32 to −0.25). The research of [3] calculated correlations indicated that milk yield was negatively genetic correlated to THI (r = –0.75). Moreover, the THI values one, two and three days prior had a greater effect on milk yield than the same day measure. The respective correlation values between milk yield and THI were –0.83, –0.87, –0.89.

Table 2 The relationship of THI on milk yield and milk composition in dairy cattle

Traits	N	Slope	SE	P-value
milk/day; kg	3437	-0.099	0.03	<0.001
fat; %	2610	0.016	0.002	<0.001
pro; %	2628	-0.004	0.005	0.164
SNF; %	2621	0.022	0.006	<0.001
TS; %	2609	0.038	0.003	<0.001

Note: N is the number of data; SE is standard error

3.4 The Effect of THI on Milk and Milk Composition

The results in Table 3 show a significant relationship (P < 0.01**)** between THI groups on milk/day, %fat, %SNF and %TS**.** The milk/day of the THI 4 group (THI >78) was lower than the THI 1 THI 2 and THI 3, with an average of 12.50, 14.04, 13.50 and 12.68 kg, respectively (P <0.01).

The %Fat, %SNF and %TS values were highest in the THI 4 range (THI> 78). The % fat in THI 3 is the highest. However, there is non-significant with THI 4, which is 3.49% and 3.48%, respectively. The %fat in THI 1 is the lowest (2.89%). Additionally, the %SNF and %TS values in THI 4 were the highest, 8.38 % and 11.86 %, respectively. The %SNF values in THI1, THI2 and THI3 were 8.09%, 8.22% and 8.13%, respectively (P> 0.05). The reason is that when the THI value is higher, the value of milk composition (%Fat, %SNF and %TS) will increase as well; milk composition values in milk having a negative correlation with the milk production. Therefore THI 1 (THI ≤70) results in the highest values of milk/day thus, resulting in low %Fat %SNF and %TS values in milk.

The research report that the third parity, test-day milk yield started to decline after a THI of 74 for cows with ≥87.5% Holstein genetics and declined more rapidly after a THI of 82 [4]. Another report in three climactic regions (East, Mediterranean and central) Croatia. Found that heat stress conditions indicated by mean daily values of THI >72 were present during spring and summer season in all regions [5]. Moreover, high THI conditions were negatively associated with milking frequency and milk yield in pasture-based automatic milking systems and that research into management and infrastructure (cow cooling) in these systems is warranted to reduce production losses [15]. Dry matter intake and milk yield declined linearly with respective increases in air temperature or THI during the hot period and milk temperature increased linearly with increasing air temperature. Dry matter intake and milk yield both exhibited a curvilinear relationship with milk temperature [16]. Heat stress had negative effects on milk production traits and SCS. The heat stress resulted in decreasing milk yield, fat, and protein percentages, and increasing SCS [17].

4. CONCLUSION

The conclusion in this study found that Mahasarakham province, Nortest of Thailand could be characterized as hot and humid with temperature between 23.57 – 30.85 °C and the average relative humidity of 72.59 %. The highest temperatures occurred between April– May (30.85 – 30.44°C) and lowest in December (23.57°C). Using the temperature and humidity to calculate Temperature Humidity Index (THI). THI was the highest in May (82.07) and the lowest in December (71.66). There was negative relationship between THI and milk yield with a slope value of -0.099. The slope value explains that when the THI value increased by 1 unit, the milk yield decreased

Table 3 The effect of THI on milk yield and milk composition

Traits	LSM								P-value
	THI 1	SE	THI 2	SE	THI 3	SE	THI 4	SE	
milk/day; kg	14.04^{a}	0.38	13.50^{a}	0.30	12.68^{b}	0.21	12.50^{c}	0.10	**
fat; %	2.89^{a}	0.02	3.39^{b}	0.04	3.49^{bc}	0.03	3.48^{c}	0.01	**
pro; %	2.96	0.07	2.92	0.03	2.87	0.02	2.90	0.01	ns
SNF;%	8.09^{a}	0.13	8.22^{a}	0.06	8.13^{a}	0.04	8.38^{b}	0.02	**
TS; %	10.98^{a}	0.16	11.61^{b}	0.08	11.59^{b}	0.05	11.86^{c}	0.02	**

Note: THI 1 = (THI ≤70), THI 2 = 74 ≤THI<70, THI 3 =78 ≤THI<74, THI 4 =THI > 78; LSM is least square means; SE is standard error; ** The effect was significance at P<0.01; a,b,c Value within the row with different superscripts are significantly different (P<0.01)

by 0.099 kg/cow/day. Dividing the THI group into 4 groups (THI 1 = THI ≤70, THI 2 = 74 ≤THI <70, THI 3 = 78 ≤THI <74, THI 4 = THI> 78), the result showed that when the highest THI (THI 4) effect on milk yield is the lowest, while THI 1 and THI 2 was effect on high milk yield. Dairy production in the tropical zone have to highly concern not only the temperature but also the humidity because the physiology of homeostasis using both of them. To balanced body temperature, cow will evaporate sweat into the environment. If the environment has high humidity, it will prevent the evaporation mechanism, heat releasing will not occure and it will cause a in decrease milk production of dairy cows.

5. ACKNOWLEDGMENTS

The research team would like to thank Khok- Koen Dairy Farm Cooperative Limited and dairy farmers, Mahasarakham Province, Thailand for milk yield and milk composition data for this study. Thank you to the Meteorological Department Kosum Phisai District Mahasarakham province, Thailand for temperature and humidity data. Thank you to Faculty of Technology, Mahasarakham University Mahasarakham province, Thailand.

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