Modification of Microclimate to Improve Milk Production in Tropical Rainforest of Thailand

W. Suriyasathaporn*, S. Boonyayatra, K. Kreausukon, T. Pinyopummintr[1] and C. Heuer[2]
Ruminant Clinic, Faculty of Veterinary Medicine, Chiang Mai University, Chiang Mai, 50100, Thailand

ABSTRACT : The objective of this study was to evaluate the effect of electric fan installation for milk production improvement of dairy cattle in Thailand. The study was conducted using 2 small-holder dairy farms in Chiang Mai province, during April to August 2004. Electric fans were installed in front of each row of cows. Each of the two rows of cows in the barn was defined as an experimental unit, thus each farm had two experimental units. The fans were operated alternately in 7-day intervals between rows of cows within each farm during the day or between 8.00 am to 8.00 pm. Non-operation periods were used as control. Milk yields were recorded. Data on environmental temperature and humidity were obtained from Chiang Mai Meteorological Center. Result from statistically analysis of milk record suggested an interaction between lactation period and fan installation. Therefore, this interaction term of lactation period and fan installation (PERIOD_FAN) was added as a variable to the regression model. Due to the repeated data collection of milk yield from the same cow (alternate week), milk yield was analyzed by repeated measure analysis (Mixed model). Least square means were calculated for all levels and used to compare between each pair-wise values. The final data were collected from the total of 18 cows with 2,072 data. Overall means and SEM of milk yields and days in milk separated into farm were 14.7±0.06 kg/day and 176.3±2.2 days, and 15.2±0.22 kg/day and 202.5±3.7 days for farm A and farm B, respectively. For multivariable analysis, only PERIOD_FAN and humidity were significantly associated with milk yield. Only the first period of lactation showed that the amount of milk yields during fan installation was higher than that of non-fan installation ($p<0.05$). Cows with fan installation produced approximately 1.2 kg/cow more milk than cows without fan installation during this period. In conclusion, the use of electric fan operated during the day time increased milk production of cows during the first period of lactation. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 6 : 811-815)***

Key Words : Dairy Cattle, Fans, Milk, Period of Lactation, Thailand

INTRODUCTION

Thailand is defined as a humid tropical country with an average monthly temperature-humidity-index (THI) of 75.7 (Johnson, 1989). The climate of the country does not preclude the use of Holstein dairy cows. However, the introduction of Holsteins would results in moderate to severe limitations in milk production potential largely due to the temperature/humidity and related nutritional factors. It was observed that milk production was reduced by high environmental temperature and humidity (Regan and Richardson, 1938; Armstrong et al., 1988).

The climate of Thailand is influenced by the seasonal monsoon and the local topography. Two distinct types of climate are recognized: tropical rain forest and tropical savannah. The tropical rain forest is characterized by uniformly high temperature and heavy rainfall without possessing any distinct dry season. The tropical savannah climate on the other hand is characterized by less precipitation with three distinct seasons, a rainy season (June to October), a hot dry season (March to May) and a cold dry season (November to February). In Thailand, severe decrease in milk production of dairy cattle due to high temperature and humidity may be expected during the rainy season (Pongpiachan et al., 2000).

Appropriate technology is required to ease the impact of heat stress on dairy cows introduced to the humid tropics especially in the summer. It was shown repeatedly that access to shade minimized radiation as much as 30% and reduced heat stress substantially (Roman-Ponce et al., 1977). Alternatively, high performance fans may have great potential in improving milk yields (Igono et al., 1987). In view of considerable seasonal variation in THI in Thailand, no information is available on the effect of electric fan installation to improve milk production. Therefore, the goal of this study was to evaluate the effect of electric fan installation on milk production in relation to the lactation period.

MATERIALS AND METHODS

Animals and farm management

The study was conducted using 2 small-holder dairy farms in Chiang Mai province, during April to August 2004. All cows (n = 18) were fed post-harvest corn stem and rice straw *ad lib*. and concentrates according to their milk production, and the vast majority of the cows were

* Corresponding Author: W. Suriyasathaporn. Tel: +66-5-394-8023, Fax: +66-5-327-4710, E-mail: switaya@chiangmai.ac.th
[1] Faculty of Veterinary Medicine, Kasetsat University, Kamphang Saen, Nakhon Pathom, 73140, Thailand.
[2] Institute of Veterinary, Animal and Biomedical Sciences, College of Sciences, Massey University, Palmerston North, New Zealand.
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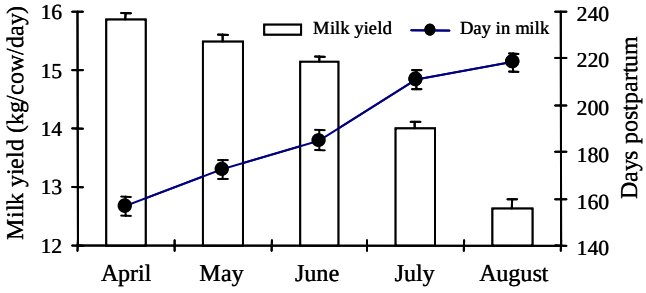

Figure 1. Means and standard error of means of milk yields and days in milk during April to August 2004, from 2 small holder dairy farms in Chiang Mai, Thailand (n = 18).

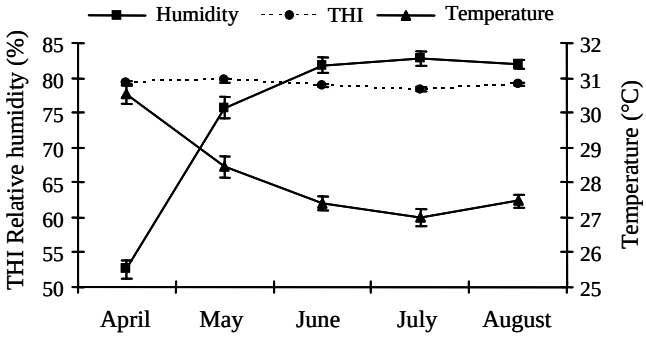

Figure 2. Means and SEM of environmental temperature, relative humidity and temperature-humidity index (THI), data from Chiang Mai Meteorological Center, during April to August 2004. Chiang Mai, Thailand.

crossbred Holstein-Friesian. The average of overall dry matter intake was 14.5 kg/cow. Dates of calving and sampling were recorded.

In both farms, milking cows were housed indoors and fed and milked in double-range dairy barns without walls according to typical herds of about sixteen cows. Cows faced inwards on to a central feeding passage. The roofs of building were approximately about 1.5 m wide overhang to provide the maximum shade and to prevent exposure to heavy rain. The floors were constructed of concrete. Cows were machine milked twice a day.

Experimental design

Electric fans with 60 centimeters in diameters, 4 poles, 0.5 hp, 200 cubic meters per minute (CMM), and 1,450 revolutions per minute (rpm) were installed in front of each row of cows. Each of the two rows of cows in the barn was defined as an experimental unit, thus each farm had two experimental units. The fans were operated alternately in 7-day intervals between rows of cows within each farm during the day or between 8.00 am to 8.00 pm. Non-operation periods were used as control. Milk yields were recorded after each milking. Data on environmental temperature and humidity were obtained from Chiang Mai Meteorological Center, Chiang Mai, Thailand.

Statistical analysis

Daily milk yield calculated as the sum of morning and evening milk adjusted for milk solids was defined as the dependent variables. Both daily averages of temperature (TEMP) and humidity (HUMID) were calculated by the averages of daily maximum and minimum values. The mean temperature-humidity index (THI) indices were fitted to the law equations (Mcdowell et al., 1979):

$$\text{Mean THI} = (0.8\times\text{TEMP})+(\text{HUMID}/100)\times(\text{TEMP}-14.4)+46.4$$

Independent variables included lactation stage in each trimester (calving to 100 d, 101 d to 200 d, and more than 200 d postpartum), TEMP, HUMID, and using fan (use, not-use). Due to the repeated data collection of milk yield from the same cow, milk yield was analyzed by repeated measure analysis, procedure mixed (SAS, 1997). Cow within farm was added as a random effect. Preliminary analysis suggested an interaction between lactation trimester and fan. Therefore, this interaction term of lactation trimester and fan (PERIOD_FAN) was added as a variable to the regression model. Least square means were calculated for all levels and used to compare between each pair-wise values. The significant level was defined at <0.05.

RESULTS

Descriptive data

The final data originated from the total of 18 cows included 2,072 data. Overall means and SEM of milk yields and days in milk separated into farm were 14.7±0.06 kg/day and 176.3±2.2 days, and 15.2±0.22 kg/day and 202.5±3.7 days for farm A and farm B, respectively. No significant difference of milk yield between farms was observed. Means and SEM of milk yields and days in milk during April to August are shown in Figure 1. Milk yield was gradually decreased based on the increase of day in milk. During the study, three cows calved on April, May, and June 2004, respectively. Data on environmental temperature and humidity during the study were expressed as means and SEM (Figure 2).

Effects of temperature, humidity and using of electric fans on milk yield

Results from univariable and multivariable analysis are shown in Table 1. For univariable analysis, all variables were associated with milk yields ($p<0.01$). Increases in temperature and humidity resulted in decrease of milk yield at 0.138 kg/°C and 0.071 kg/% of humidity. For multivariable analysis, only PERIOD_FAN and HUMID were significantly associated with milk yield.

Least square means and SEM of each value in the

Table 1. Results from univariable and multivariable analysis showing the effect of using fan, periods of lactation, temperature and humidity on milk yield (Data from 18 cows during April to August 2004, Chiang Mai province, Thailand)

Variable	Estimate	SEM	F-value	p value
Univariable analysis				
Period (fan)			85.17	<0.0001
Temp.	-0.14	0.05	7.91	0.005
Humid	-0.07	0.01	102.26	<0.0001
Multivariable analysis				
Period (fan)			47.54	<0.0001
Temp.	-0.06	0.05	1.14	0.23
Humid	-0.04	0.01	37.16	<0.0001

PERIOD_FAN variable are shown in Figure 3. Only the first trimester of lactation showed that the amount of milk yields during using fans had higher yield than that of non-using fan ($p<0.05$). Using fan received approximately 1.2 kg of milk per cow more than non-using fan during this period.

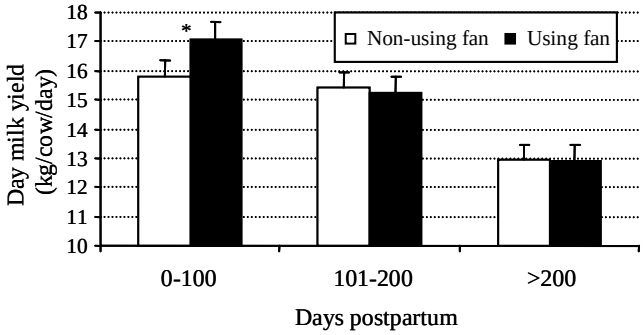

Figure 3. Least square means and SEM of each value in the period (fan) variable including 3 lactation periods (0-100, 101-200, and >200 days postpartum) and using fan (using and non-using fan). Asterisk indicates $p<0.05$ in comparison between using and non-using in the same lactation period.

DISCUSSION

During hot-dry and rainy seasons in Thailand, the average temperature is always higher than 27°C with the mean THI more than 78 (Figure 2). This temperature is higher than the upper critical temperature for lactating cows (Fuquay, 1981; Berman et al., 1985), or when the THI exceeds 72 (Armstrong, 1994). The temperature in this study is similar to Israel during May to October (Barash et al., 2001). However, the humidity in Thailand is relatively high during rainy season (>80%) which results in further decrease in milk production of dairy cattle (Bianca, 1965). Therefore, the use of the result in this study would limit on the area with high humidity and high temperature in tropical countries.

The average milk production in this study was range 14.7 to 15.3 kg/day during 176 to 202 days postpartum. This milk production level is in the high-production herd in Thailand (Tumwasorn et al., 1999; Suriyasathaporn et al., 2003). The average of test day milk yield in Thailand ranges between 9 to 14 kg/day (Pongpiachan et al., 2000; Suriyasathaporn et al., 2002; Kaewkamchan et al., 2003). Based on the limitation of data used in this study, this may lead to bias in case that these two farms are not representative of other farms in the population. The complete randomized design used in this study might minimize the bias based on farm management. However, the result of this study must be carefully used with regard to temperature and humidity and milk production levels.

Effect of environmental temperature and humidity on milk yield

Univariable analyses indicated that all variables were associated with milk yield (Table 1). Temperature and humidity decreased and fan installation increased milk yields. The negative effect of high temperature and humidity on milk yield are supported by the studies in the southeastern United States and Israel (Barash et al., 2001; Ravagnolo and Misztal, 2002; for review see West, 2003; West et al., 2003). During the rainy season in Thailand, when the temperature and humidity are relatively high, milk yield was lowest and fat, protein, and SNF contents were highest (Kaewkamchan et al., 2003).

The depressive effect of temperature on milk yield found in this study was lower than that in Israel (Barash et al., 2001), possibly because of the narrower and higher range of average temperature in this study (27 to 31°C) compared to the Isreali study (12.5 to 27.1°C). A rise in relative humidity may lead to stronger reduction in milk yield (Bianca, 1965; Bayer et al., 1980). As the primary non-evaporative means of cooling for the cow (radiation, conduction, and convection) become less effective with rising ambient temperature, the cow becomes increasingly reliant on evaporative cooling in the form of sweating and panting (West, 2003). High relative humidity compromises evaporative cooling, so that under hot, humid conditions the dairy cow cannot dissipate sufficient body heat to prevent a rise in body temperature (West, 2003) and decrease in milk yield (Ominski et al., 2002). In addition, a study in goats have been shown that goats in a hot environment decrease their feed intake and ruminating time, and increase time spend eating (Hirayama and Katoh, 2004).

Effect of fan on milk yield

In our multivariable analysis, the using of fan adjusted for period of lactation and humidity variables and temperature, were related to milk yield. However, temperature was not associated with milk yield when fan installation and humidity were considered. This indicates that using a fan may reduce the adverse thermal effect but

to a lesser extent than that of humidity on milk production. In addition, the effects of both environmental factors on milk production were reduced after the entering of fan factor in the final model.

In the present study, the beneficial effect of fan installation on milk production only existed during the first trimester of lactation (Figure 3). This agrees with an earlier study in Thailand that the effects of temperature and humidity on milk yield in 75% crossbreds dairy cows appeared only during the first trimester of lactation (Pongpiachan et al., 2000). Due to a rapid increase of milk production immediately after calving, most cows are in negative energy balance within the first trimester of lactation (Suriyasathaporn et al., 2000). Maximizing dry matter intake is important to minimize postpartum complications and losses in milk production (Grummer et al., 2004). Increasing air temperature, humidity, and subsequently rising rectal temperature are related to decreased dry matter intake and consequently loss in milk yield (West, 2003; West et al., 2003). Therefore, it is possible that the use of fans might relieve the negative effects of hot-humid environment on milk production by increasing dry matter intake.

In conclusion, temperature and humidity are negatively associated with milk yield in dairy cattle during hot-dry and rainy (hot-humid) seasons in Thailand. The use of electric fan operated during the day time increases milk production of cows during the first trimester of lactation.

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