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Effect of Experience, Education, Record Keeping, Labor and Decision Making on Monthly Milk Yield and Revenue of Dairy Farms Supported by a Private Organization in Central Thailand*

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ABSTRACT : The objective of this research was to assess the effect of experience, education, record keeping, labor, and decision making on monthly milk yield per farm (MYF), monthly milk yield per cow (MYC), monthly milk revenue per farm (MRF), and monthly revenue per cow (MRC) of dairy farms supported by a private organization in Central Thailand. The dataset contained 34,082 monthly milk yield and revenue records collected from January 2004 to December 2008 on 497 farms, and information on individual farmer experience and education, record keeping, and decision making obtained with a questionnaire. Farmer experience categories were i) no experience, ii) one year, iii) two to five years, iv) six to ten years, v) eleven to fifteen years, vi) sixteen to twenty years, and vii) more than twenty years. Farmer education categories were i) no education or primary school, ii) high school, and iii) bachelor or higher degree. Record keeping categories were: i) no records and ii) kept records. Labor categories were: i) family, ii) hired people, and iii) family and hired people. Decision making categories were: i) decisions made by farmers themselves, ii) decisions made with help from government officials, and iii) decisions made with help from organization staff. The mixed linear model contained the fixed effects of year-season, farm location-farm size subclass, experience, education, record keeping, labor, and decision making on sire selection, and the random effects of farm and residual. Results showed that longer experience increased ($p<0.05$) monthly milk yield (MYF and MYC) and revenue (MRF and MRC). Farms that hired people produced the highest ($p<0.05$) monthly milk yield (MYF and MYC) and revenue (MRF and MRC), followed by farms that used family, and the lowest values were for farms that used both family and hired people. Better educated farmers produced more MYC and MRC ($p<0.05$) than lower educated farmers. Farms that kept records had higher MYF and MRF ($p<0.05$) than those without records. Although differences among farms were non-significant, farms that received help from the organization staff had higher monthly milk yield (MYF and MYC) and revenue (MRF and MRC) than those that decided by themselves or with help from government officials. These findings suggested that dairy farmers needed systematic training and continuous support to improve farm milk production and revenues in a sustainable manner. (**Key Words :** Dairy Farming, Milk Production, Revenue, Farmer, Tropics)

INTRODUCTION

Under the current high level of economic competition, farmers need to increase their efficiency of production of high-quality milk and lower costs to improve the profitability of their operations. Identification of factors that affect milk production and revenue and their economic importance is necessary to help dairy farmers manage their limited resources and economic opportunities would help them improve their productivity and their ability to stay in business. This information would also help dairy cooperatives and private organizations to provide more appropriate and effective support to their members.

Thailand is a tropical country in Southeast Asia (5° 37′ to 20° 27′ North latitude and 97° 22′ to 105° 37′ East longitude) characterized by high temperature (23.1°C to 29.6°C) and high humidity (66% to 81%; Thai Meteorological Department, 2009). Central Thailand has the largest number of cows and farms in the country. Milk produced in this region amounted to 1,080 tons/d (67% of

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the whole country) in 2008. This amount of milk was produced by 144,586 milking cows (70% of the country) raised in 12,264 dairy households (64% of the country; Department of Livestock Development, 2009) and then sold to a dairy cooperative or a private organization where the farmer was a member.

Year-season and farm location-farm size subclasses were found to have effect on milk production (Rhone et al., 2008b; Yeamkong et al., 2009) and milk revenue of dairy farms (Yeamkong et al., 2009) in Central Thailand. Ratios of individual farm variance to total variance for milk yield and milk revenue (0.30 to 0.52; Yeamkong et al., 2009) suggested that factors related to farmers themselves such as experience, education, record keeping, labor, and decision making on sire selection could also have an effect on milk yield and milk revenue. Tomaszewski (1993) reported that record keeping systems had provided an essential link that significantly increased milk production. Rhone et al. (2008c) found that farms that kept records did not have significantly higher milk yields than farms that kept no records. Hanna et al. (2006) found that cows that had more positive interactions with the stockperson had higher milk yields.

Few studies concerning farmers' experience and education background exist in Thailand (Boonyanuwat et al., 1995; Borisutsawat, 1996). Further, no study in Thailand has considered the effect of all these human factors (i.e., experience, education, record keeping, labor and decision making on sire selection) on milk production, and none of them studied their impact on milk revenue. Thus, the objective of this research was to assess the effect of experience, education, record keeping, labor, and decision making on monthly milk yield and revenue of dairy farms supported by a private organization in Central Thailand.

MATERIALS AND METHODS

Dataset and study area

A dataset with 34,082 records collected monthly from January 2004 to December 2008 from 800 dairy farms was provided by a private dairy organization (Midland Dairy Limited Partnership; MDLP). In addition, individual farm information was gathered from all participating dairy farmers using a questionnaire. All dairy farms in the dataset were located in Central Thailand. Farm locations (Figure 1) were classified according to districts defined by the Thai government as Muak Lek (Saraburi province), Wang Muang (Saraburi province), Phatthana Nikhom (Lop Buri province) and Pak Chong (Nakhon Rachasima province). Seasons were classified (Thai Meteorological Department, 2007) as winter (November to February; cool (21°C to 32°C) and dry (70% RH, precipitation 124 mm/year), summer (March to June; hot (25°C to 36°C) and dry (69% RH, precipitation 187 mm/year)), and rainy season (July to October; hot (24°C to 33°C) and humid (79% RH, precipitation 903 mm/year). Farms were classified according to their average number of milking cows per day into small (less than 10 milking cows), medium (from 10 to 19 milking cows), and large (more than 19 milking cows).

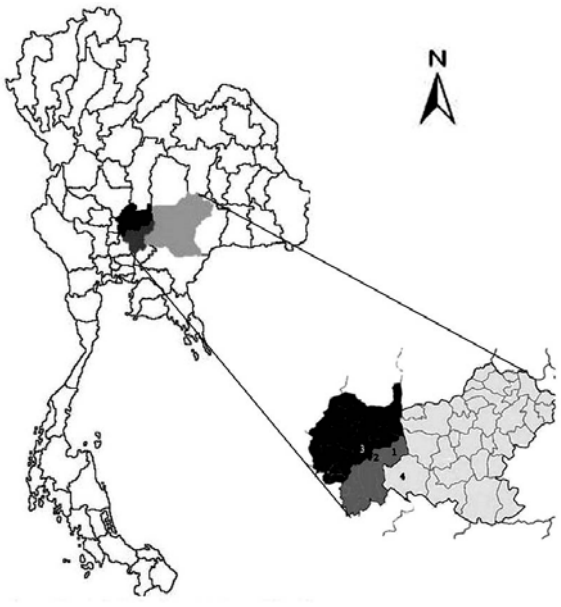


Figure 1. Map of Thailand showing the districts where farms were located: 1 = Muak Lek (Saraburi province), 2 = Wang Muang districts (Saraburi province), 3 = Phatthana Nikhom (Lop Buri province), and 4 = Pak Chong (Nakhon Ratchasima province).

Farms, animals and management

The average size of each farm was approximately 4 acres (SD = 6 acres). The majority of dairy farmers in this population (52.4%) depended on their dairy business as the sole source of income. The remaining farmers received additional income from other livestock trade (2.9%), horticulture or agronomy (41.2%), and other sources (3.5%). Each farm employed approximately 2 people (SD = 0.8 people), and in most farms (89.0%) employees were members of the family.

The average number of dairy cattle in each farm was 29 (SD = 20) for all types of dairy cattle, and 11 (SD = 8) for milking cows. The largest group of milking cows in these farms were crossbreds with Holstein (H) fractions ranging from 51% to 75% (47% of the population), followed by crossbreds with H fractions larger than 75% up to less than 100% (43.5% of the population), crossbreds with H fraction less than 50% (7.8% of the population), and purebred H (1.7% of the population). Other breeds, in addition to H, represented as fractions in this population were Brahman, Brown Swiss, Jersey, Red Dane, Red Sindhi, Sahiwal, and Thai Native. The number of breeds represented in a particular cow ranged from one to more than 8 different

breeds. Most farms (49.3%) preferred to use purebred H rather than crossbred H (32.5%) sires or sires from other dairy breeds (10.0%) or beef breeds (8.2%) to breed their cows by artificial insemination. Farmers used their own experience and/or advise from the government or private organization to select sires. Dairy cows were vaccinated against Foot and Mouth Disease (FMD), and were treated against parasites twice a year.

Most farmers (86.5%) had areas dedicated to grasses or legumes. Feeding and nutrition varied among seasons. Grasses represented in this region were *Brachiaria mutica* (para grass), *Brachiaria ruziziensis* (ruzi grass), *Pennisetum purpureum* (napier grass) and *Panicum maximum* (guinea grass). Most farmers (57%) cut-and-carried these forages to their cattle and also prepared pastures for grazing. Other farmers either only cut-and-carried grass (39%), or prepared pastures for grazing (4%). During the dry seasons (winter and summer), when green roughage was limited (usually due to lack of irrigation), rice straw, hay, and silage were used as supplements. Farmers also used concentrate composed of cereal, grains, rice bran, mung bean, soybean meal, minerals, vitamins, and byproducts from various milling and industrial plants (e.g., cotton meal, oil palm meal, and coconut meal). Most farmers purchased their concentrate as ready-mixed feeds (90.6% of farmers), whereas 6.3% of farmers mixed their own concentrate, and 3.1% of farmers fed both home-mixed and purchased concentrate. Concentrate was purchased from companies such as B.P. Feed Mill Co. Ltd., (Bangkok; feeds contain about 14%, 16% and 21% crude protein), Thai Feed Mills (Saraburi) Co. Ltd., (Saraburi; feeds contain about 16% crude protein), Betagro Public Company Limited (Saraburi; feeds contain about 14%, 16%, and 21% crude protein), and Chokchai Ranch Co. Ltd., (Nakhon Rachasrima; feeds contain about 16% crude protein). The amount of concentrate fed to cows depended largely on the amount of milk produced by individual cows. Generally, one kilogram of concentrate was fed for each 2 to 3 kg of milk produced. Farmers usually fed milking cows twice a day, once after they were milked in the morning (4:30 to 7:00) and again in the afternoon (14:30 to 16:30). Some farmers fed their cows during milking. Almost all dairy farms used machine (95%) rather than hand (5%) milking. Milk was stored in 50 kg bulk tanks that were taken to the MDLP by either the farmers themselves (15%) or by hired people (85%).

Traits and data preparation

Traits in the MDLP dataset were: i) monthly milk yield per farm (MYF; kg), which was the total amount of milk produced by an individual farm in a particular month, ii) monthly milk yield per cow (MYC; kg), which was calculated as MYF divided by the average number of milking cows per day at an individual farm in a particular month, iii) monthly milk revenue per farm (MRF; baht), which was the total revenue from milk sold by a farm to the MDLP in a particular month, and iv) monthly milk revenue per cow (MRC; baht), which was computed as MRF divided by the average number of milking cows per day at an individual farm in a particular month.

Individual farm information was obtained using a questionnaire, which contained three types of questions: multiple choice, fill in the blank, and choose all that apply. Questions requested information of farmers' background, farm management, and decision making on sire selection. The questionnaire was pre-tested using eight dairy farms chosen randomly in the area of the study. After changes were made to improve its clarity, questionnaires were randomly distributed to the 800 dairy farmers in the original dataset provided by MDLP. Three weeks later, filled questionnaires were collected (627 farms; 78% response rate) and sent back to Kasetsart University for data entry and analyses. Answers to each question were assigned a numeric code that could be used for data analyses. Experience of the farmer, measured as the number of years a farmer had been dairying, was classified as: i) no experience, ii) one year of experience, iii) two to five years of experience, iv) six to ten years of experience, v) eleven to fifteen years of experience, vi) sixteen to twenty years of experience, and vii) more than twenty years of experience. Education of the farmer, measured as the farmer's highest educational degree, was classified as: i) no education or primary school, ii) high school, and iii) bachelor or higher degree. Record keeping for milk production and pedigree information of the farm were defined as in Rhone et al. (2008c), i.e., i) no records, and ii) kept records. Labor, defined in terms of type of workers that participated in dairy operations, was categorized as: i) family, ii) hired people, and iii) family and hired people. Decision making on sire selection was classified as: i) decisions made by farmers themselves, ii) decisions made with help from government officials, and iii) decisions made with help from organization staff.

The MDLP monthly milk yield and revenue dataset was linked to the questionnaire dataset through farm identification number and combined into a single dataset. Then, the combined dataset was edited for missing and erroneous information. The resulting dataset contained 24,249 records from 497 farms with complete information on farmer's experience, education, record keeping, labor, and decision making on sire selection.

Statistical analysis

The dataset was analyzed using a mixed linear model that contained year-season subclass, farm location-farm size subclass, experience of the farmer, education of the farmer, record keeping of the farm, labor, and decision making on

sire selection as fixed effects, and farm and residual as random effects. Random farm effects were assumed to have mean zero, a common variance (σ_f^2), and uncorrelated. Random residual effects were assumed to have mean zero, a common variance (σ_e^2), and uncorrelated. Variances for random effects were estimated using a restricted maximum likelihood procedure. Analyses were performed using the MIXED procedure of the Statistical Analysis System (SAS, 2006). Least square means (LSM) were estimated for each trait and pairwise comparisons made using Bonferroni t-tests. The significance level for comparisons was set to α = 0.05.

RESULTS AND DISCUSSION

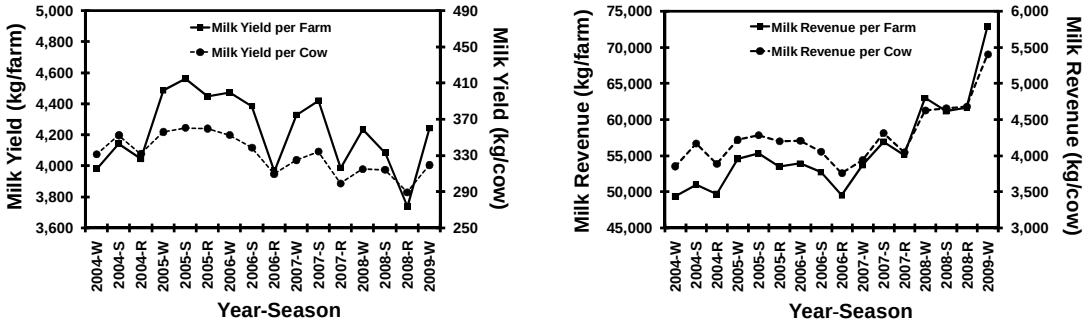
Year-season subclasses

Monthly milk production per farm and per cow (Figure 2A) and revenue per farm and per cow (Figure 2B) varied across year-season subclasses. Year-season LSM ranged from 3,737.67±191.39 kg (2008, Rainy) to 4,561.86± 190.90 kg (2005, Summer) for MYF, 289.56±9.59 kg (2008, Rainy) to 360.34±9.55 kg (2005, Summer) for MYC, 49,374.00±2,480.48 baht (2003, Winter) to 72,930.00± 2,436.00 baht (2008, Winter) for MRF, and 3,759.90± 135.97 baht (2006, Rainy) to 5,399.72±141.98 baht (2008, Winter) for MRC. Monthly milk production tended to decrease per farm (MYF = -12.09±12.95 kg/year-season; $p>0.05$) and per cow (MYC = -3.27±0.86 kg/year-season; $p<0.01$) from 2004 to 2008. Contrarily, monthly revenues tended to increase by farm (MRF = 1,037.89±209.80 baht/year-season; $p<0.01$) and by cow (MRC = 58.46±16.94 baht/year-season; $p<0.01$) during this period.

Decreasing trends for monthly milk production (MYF and MYC) and increasing trends for monthly milk revenue (MRF and MRC) may have been associated with the current economic situation in Thailand (Yeamkong et al., 2009). Farm milk revenues decreased during the period of the study. Dairy production costs increased by 58.4% (from 8.51 baht/kg in 2004 to 13.48 baht/kg in 2008), but the price of raw milk increased by only 44.0% (from 12.50 in 2004 to 18.00 baht/kg in 2008; Office of Agricultural Economics, 2009). Price of raw milk remained steady at 12.50 baht/kg from January 2004 to March 2007 (39 months). It subsequently increased to 13.75 baht/kg for 4 months (April through August 2007), and to 14.50 baht/kg for 10 months (September 2007 to June 2008), and finally rose to 18.00 baht/kg in July 2008. It remained at this price until the end of the study (6 months). Differences in rates of increase of milk production costs and price of raw milk may have forced farmers to reduce the quality and quantity of nutrition, management, and health care of their cows, which in turn may have negatively affected their productive ability resulting in lower MYF and MYC.

Farm location-farm size subclasses

Monthly milk production per farm (MYF) and per cow (MYC) and revenues per farm (MRF) and per cow (MRC) varied across farm location-farm size subclasses ($p< 0.0001$). The LSM for MYF ranged from 2,582.32±294.32 kg (Phatthana Nikhom) to 3,094.68±193.91 kg (Muak Lek) for small farms, from 3,882.84±296.50 kg (Phatthana Nikhom) to 4,254.41±309.69 kg (Pak Chong) for medium farms, and from 5,005.63±198.46 kg (Muak Lek) to 7,060.29±324.46 kg (Pak Chong) for large farms (Table 1). The LSM for MYC ranged from 373.69±14.27 kg (Phatthana Nikhom) to 391.447±14.84 kg (Pak Chong) for small farms, 319.99±14.48 kg (Phatthana Nikhom) to 335.41±15.09 kg (Pak Chong) for medium farms, and 259.88±10.02 kg (Muak Lek) to 308.94±16.77 kg (Pak Chong) for large farms (Table 1).



(A) (B)

Figure 2. Trends for year-season least squares means for monthly milk yield per farm and milk yield per cow (A) and milk revenue per farm and milk revenue per cow (B) from 2004 to 2009. Monthly milk yield tended to decrease per farm (-12.09±12.95 kg/year-season; $p>0.05$) and per cow (-3.27±0.86 kg/year-season; $p<0.01$), whereas monthly milk revenue tended to increase per farm (1,037.89±209.80 baht/year-season; $p<0.01$) and per cow (58.46±16.94 baht/year-season; $p<0.01$).

Table 1. Least squares means and standard errors for milk yield per farm, milk yield per cow, milk revenue per farm, and milk revenue per cow by farm location-farm size subclass

Farm location[1]	Farm size[2]	Milk yield per farm (kg)	Milk yield per cow (kg/cow)	Milk revenue per farm (baht)	Milk revenue per cow (baht/cow)
ML	Small	3,094.68±193.91	390.10±9.47	40,235.00±2,426.31	5,177.79±135.18
	Medium	3,978.63±194.29	322.60±9.51	51,874.00±2,431.60	4,128.97±135.86
	Large	5,005.63±198.46	259.88±10.02	67,757.00±2,489.85	3,127.19±143.27
WM	Small	2,889.76±272.72	384.95±13.28	38,008.00±3,411.11	5,075.63±189.38
	Medium	3,896.47±273.65	322.49±13.36	49,939.00±3,424.03	4,122.28±190.73
	Large	5,515.59±296.32	285.56±16.02	73,418.00±3,739.38	3,384.77±228.81
PN	Small	2,582.32±294.32	373.69±14.27	34,147.00±3,678.81	5,079.04±202.58
	Medium	3,882.84±296.50	319.99±14.48	50,592.00±3,709.34	4,151.88±206.31
	Large	5,772.56±313.48	271.30±16.46	78,142.00±3,946.62	3,629.07±236.12
PC	Small	2,706.63±307.59	391.47±14.84	35,641.00±3,845.30	5,011.64±211.78
	Medium	4,254.41±309.69	335.41±15.09	55,817.00±3,874.99	4,283.52±215.63
	Large	7,060.29±324.46	308.94±16.77	94,913.00±4,080.89	4,040.71±240.97

[1] ML = Muak Lek; WM = Wang Muang; PN = Phatthana Nikhom; PC = Pak Chong.
[2] Small = less than 10 milking cows per day; Medium = from 10 to 19 milking cows per day; Large = 20 or more milking cows per day.

The pattern of farm location-farm size LSM for MRF across locations was similar to MRC, except for small farms. The LSM for MRF ranged from 34,147.00±3,678.81 baht (Phatthana Nikhom) to 40,235.00±2,426.31 baht (Muak Lek) for small farms, from 49,939.00±3,424.03 baht (Wang Muang) to 55,817.00±3,874.99 baht (Pak Chong) for medium farms, and from 67,757.00±2,489.85 baht (Muak Lek) to 94,913.00±4,080.89 baht (Pak Chong) for large farms (Table 1). The LSM for MRC ranged from 5,011.64±211.78 baht (Pak Chong) to 5,177.79±135.18 baht (Muak Lek) for small farms, from 4,122.28±190.73 baht (Wang Muang) to 4,283.52±215.63 baht (Pak Chong) for medium farms, and from 3,127.19±143.27 baht (Muak Lek) to 4,040.71±240.97 baht (Pak Chong) for large farms (Table 1).

Large farms had higher MYF and MRF, but lower MYC and MRC than medium and small farms in all locations. These trends for MYF an MRF were related to number of milking cows. Large farms had larger number of milking cows that produced more milk and received higher revenues than smaller farms. In contrast, trends for MYC an MRC were associated with ability to produce milk of individual cows as well as quality of management, nutrition, and health care in a particular farm. Owners of large farms may not have been able to provide the same level of care and supervision per individual cow as owners of smaller farms (Kivaria et al., 2006; Seangjun and Koonawootrittriron, 2007, Rhone et al., 2008b). Owners of large farms had to hire employees who may have had insufficient knowledge and ability to perform dairy tasks, resulting in lower levels of milk production per cow. Thus, it appears that large size farms may need to improve their management practices and the training and quality control of their labor force.

Experience

Experience of farmers was important for all traits ($p< 0.001$). MYF, MRF, MYC, and MRC increased with level of experience from category 1 (0 yr) to category 7 (>20 yr). LSM increased from 2,670.66±245.08 kg to 5,107.89± 208.77 kg ($p<0.001$; Figure 3A) for MYF, from 269.08± 15.40 kg to 365.79±11.20 kg ($p<0.001$; Figure 3B) for MYC, from 37,575.00±3,134.21 baht to 68,503.00± 2,637.19 baht for MRF ($p<0.001$; Figure 3C) and from 3,405.34±220.82 baht to 4,724.15±160.75 baht for MRC ($p<0.001$; Figure 3D).

These results suggested that farmers with more years of experience likely had a better understanding and know how to appropriately manage their dairy herds under tough climatic and economic conditions than less experienced farmers. More experienced farmers fed and managed their herds better, produced more milk, and received higher revenues than less experienced farmers. More experienced farmers were able to provide cows with better management (e.g., cleaner stables, better water access, and more comfortable milking practices), better nutrition (e.g., cheaper food alternatives of high nutritional value in difficult economic times such as corn silage, grass silage, brewer grain, dry leucaena leaf, and cassava leaves), and better health care because of their higher knowledge of how to treat common diseases (e.g., tick fever, mastitis, acidosis, laminitis) without calling veterinarians, thus keeping costs low. These results were in agreement with studies that reported a positive association between farmers' experience and accumulated 305-d milk production (Jindatajak et al., 2004) and yearly milk production (Boonyanuwat et al., 1995) of individual animals raised under Thai tropical conditions.

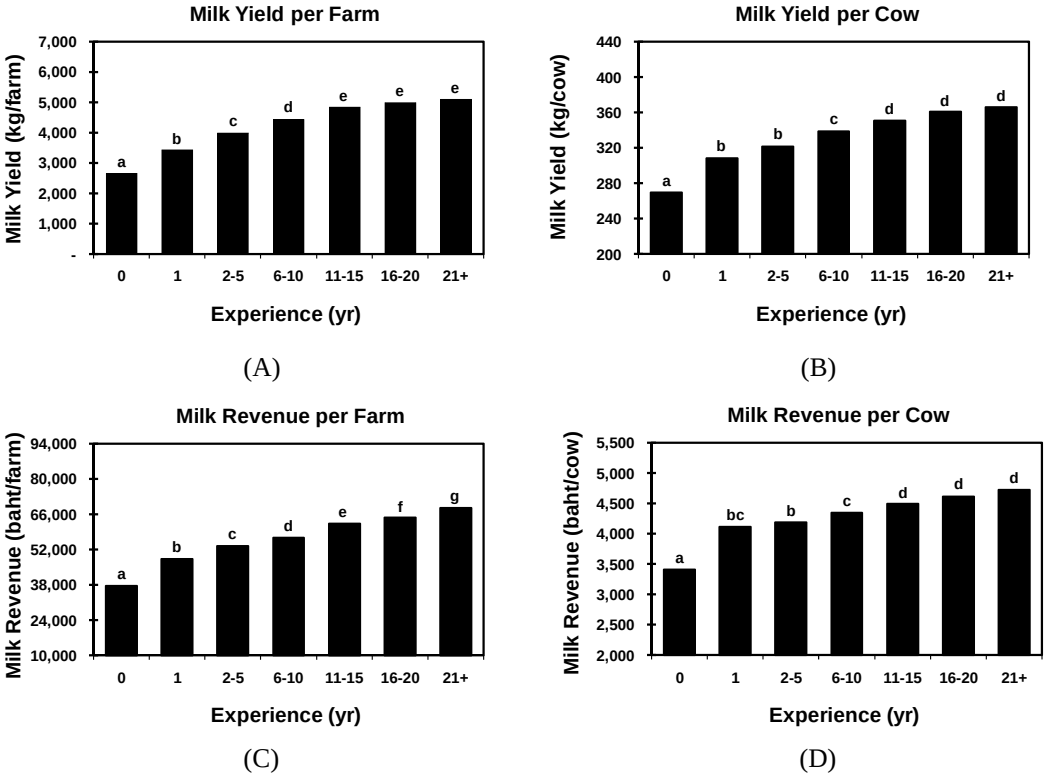


Figure 3. Least squares means for monthly milk yield per farm (A), milk yield per cow (B), milk revenue per farm (C), and milk revenue per cow (D) by level of experience of farmers. Different letters above bars indicate significant differences ($p<0.0001$ to $p<0.0402$).

Education

Monthly milk production and revenue per farm and per cow increased with the level of education of the farmer. However, LSM differences were significant only for milk production and revenue per cow, but not for monthly milk production and revenue per farm. Farmers with no education or primary school had significantly lower LSM values than those from farmers that had bachelor or higher degrees for MYC (314.00±9.43 kg vs. 347.21±13.65 kg; $p<0.05$; Figure 4B) and MRC (4,028.65±134.69 baht to 4,531.78±193.97 baht; $p<0.01$; Figure 4D), whereas non-significant differences existed for MYF (4,031.21±192.47 kg vs. 4,508.74±285.48 kg; $p>0.05$; Figure 4A) and MRF (53,738.00±2,408.94 baht vs. 59,175.00±3,565.30 baht; $p>0.05$; Figure 4C). Farmers that had bachelor or higher degree had higher MYF (11.9%), MYC (10.6%), MRF (10.1%), and MRC (12.5%) than farmers with no education or primary school. Similarly, farmers that had high school education had higher MYF (2.2%), MYC (5.2%), MRF (1.8%), and MRC (5.3%) than farmers with no education or primary school.

Educational level of farmers may be an indicator of their ability to adopt appropriate technologies and management practices (Borisutsawat, 1996; Kanchanasinith, 1999; Thijae, 1999; Cicek et al., 2007). Farmers that had a higher educational level may have had superior ability to access and understand information and technology, and may have been able to apply them more appropriately to their conditions than farmers with lower education. It appears that better educated farmers may have been able to more accurately identify and keep larger number of high production cows, thus their farms produced more milk and they earned higher revenues than lesser educated farmers.

Most dairy farmers in this study (65%) had no education or primary school, 25% had high school level, and 10% had bachelor or higher degree level. The large number of Thai dairy farmers that had no education or primary school found here was close to the fraction reported in the literature (Uthaiwan, 1992; Borisutsawat, 1996; Thijae, 1999; Rhone et al., 2008a). The large number of farmers in this group may present a challenge when promoting new technologies or disseminating knowledge for improving dairy production and profitability (Borisutsawat, 1996; Thijae, 1999). To overcome these limitations, farmers would need to receive systematic training and continuous support from dairy cooperatives, government organizations, and private organizations involved in dairy production in Thailand.

Record keeping

Record keeping had a significant effect on milk production and revenue per farm ($p<0.05$), but not on milk production and revenue per cow ($p>0.05$). Farms that kept

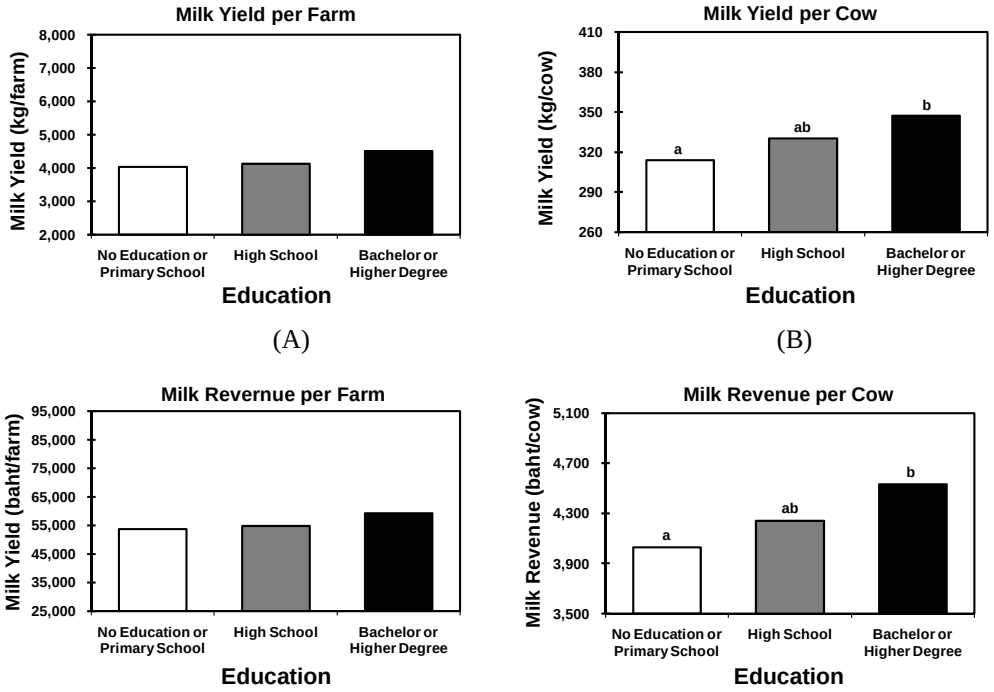


Figure 4. Least squares means for monthly milk yield per farm (A), milk yield per cow (B), milk revenue per farm (C), and milk revenue per cow (D) by level of education of farmers. Different letters above bars indicate significant differences ($p<0.0126$ to $p<0.0219$).

records had LSM of 4,408.70±230.95 kg for MYF (Figure 5A), 338.80±11.15 kg for MYC (Figure 5B), 58,375.00±2,886.98 baht for MRF (Figure 5C), and 4,385.60±158.88 baht for MRC (Figure 5D). Farms that had no records had LSM of 4,031.26±188.28 kg for MYF, 322.26±9.20 kg for MYC, 53,373.00±2,356.01 baht for MRF, and 4,149.82±

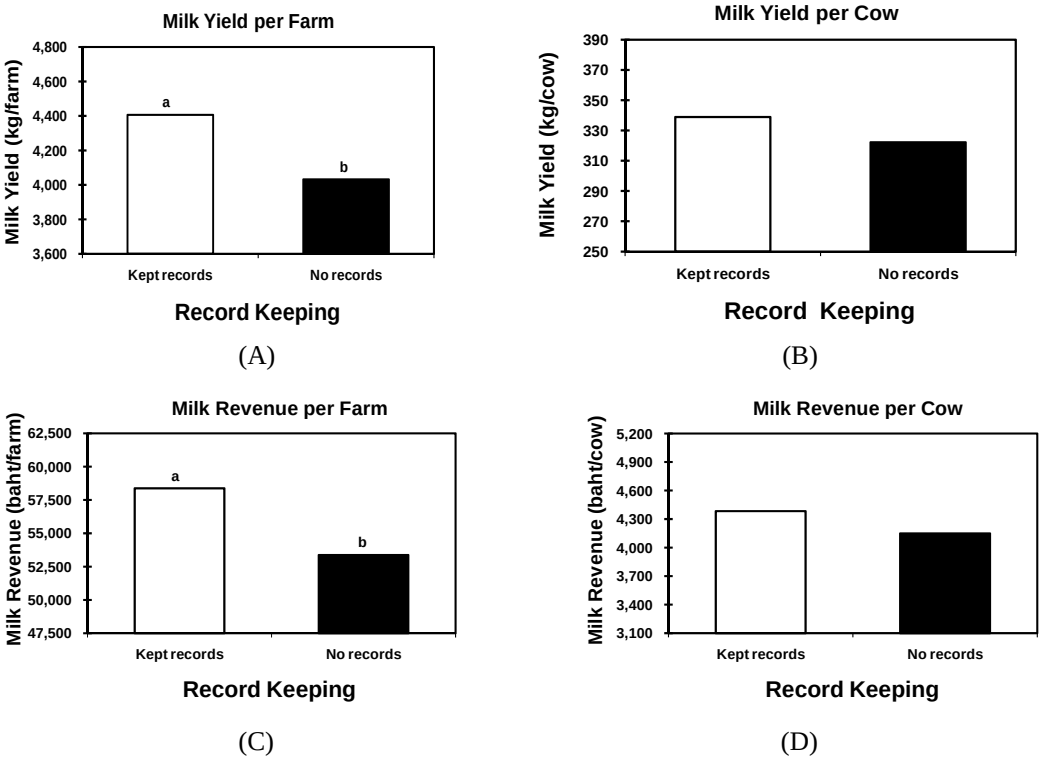


Figure 5. Least squares means for monthly milk yield per farm (A), milk yield per cow (B), milk revenue per farm (C), and milk revenue per cow (D) by record keeping category. Different letters above bars indicate significant differences ($p<0.0337$ to $p<0.0457$).

131.40 baht for MRC. Farms that kept records had higher LSM for MYF (377.44 kg or 9%: $p<0.05$), MYC (16.54 baht or 5%; $p>0.05$), MRF (5,002.00 baht or 9%; $p<0.05$), and MRC (235.78 baht or 6%; $p>0.05$) than those that did not keep records.

Higher LSM for milk production per farm and per cow found here were in agreement with results reported in the literature for dairy production in Thailand (Borisutsuwat, 1996; Suphalux, 2001; Rhone et al., 2008c) and in other countries (Tomaszewski, 1993; Losinger and Heinrichs, 1996). Farms that kept records likely used them for monitoring, planning, culling and selection decisions, and improving management efficiency. Seventy eight percent of all farms did not keep records in this population. This finding was similar to previous reports (Kanchanasinith, 1999; Wittayagone, 1999; Rhone et al., 2008a). However, results here suggest that record keeping needs to be promoted as a way to improve the accuracy of decisions made by dairy farmers because it could lead to increases in both milk production and revenue (Tomaszewski, 1993; Losinger and Heinrichs, 1996). Encouraging record keeping should be an integral part of a systematic training and continuous support dairy program in Thailand. Active involvement of dairy related organizations (Department of Livestock Development, Dairy Farming Promotion Organization, Dairy Cooperatives, and private milk collecting companies) to explain the benefits and encourage Thai farmers to keep records would likely greatly enhance its rate of adoption.

Labor

Type of labor was important for all traits ($p<0.0001$). Farms that employed their own family had LSM of 4,147.44±184.91 kg for MYF (Figure 6A), 329.67±8.82 kg for MYC (Figure 6B), 54,460.00±2,309.35 baht for MRF (Figure 6C), and 4,231.87±125.60 baht for MRC (Figure 6D). Farms that hired people had LSM of 4,608.14±215.14 kg for MYF, 344.43±12.09 kg for MYC, 62,028.00± 2,726.20 baht for MRF, and 4,499.37±174.26 baht for MRC. Farms that employed their own family and also hired people had LSM of 3,904.37±187.45 kg for MYF, 317.48±9.14 kg for MYC, 51,132.00±2,344.67 baht for MRF, and 4,071.88 ±130.19 baht for MRC.

Although farms that hired people had higher LSM than farms that used their own family for all traits, differences were significant only for MYF and MRF ($p<0.0001$). On the other hand, farms that hired people had significantly higher LSM than farms that used both family members and hired labor for all traits ($p<0.0001$). Similarly, farms that used only family labor had higher LSM than farms that used family members and hired labor for all traits ($p< 0.0001$). Differences in LSM among these three types of farms may be related to work efficiency, which may have

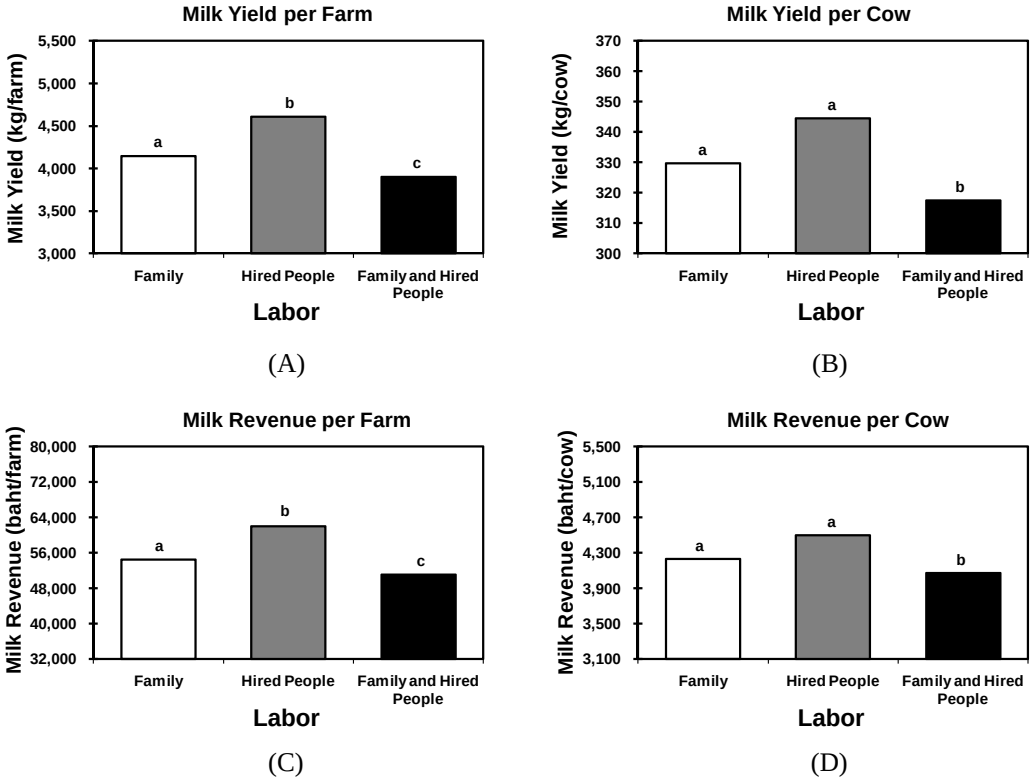


Figure 6. Least squares means for monthly milk yield per farm (A), milk yield per cow (B), milk revenue per farm (C), and milk revenue per cow (D) by type of labor. Different letters above bars indicate significant differences ($p<0.001$ to $p<0.006$).

been associated with differences in skill and level of specialization, type of facilities, ability and experience of individual workers, use of standardized work routines, and management ability (Bewley et al., 2001; Ngongoni et al., 2006). It is also possible that owners of farms that used hired workers had more available time to control the quality of work, and also devoted more time to find new information and technology, good-quality feed, and semen from good sires than owners of farms in the other two labor categories. Lastly, a better integrated and more efficient working environment with fewer problems may have helped farms that employed only family members to produce more milk than those that used both family members and hired workers.

Most farms in this population used family members only (85%), followed by farms that used both family and hired people (10%), and farms that used hired people only (5%). This distribution was similar to that reported by Borisutsuwat (1996), Garcia et al. (2005), and Rhone et al. (2008a, 2008c). Farms that used only family members as employees may not be able to increase their number of milking cows. Thus, to increase milk production and profitability, these farms may have to adopt new technologies that increase their efficiency and level of milk production. To achieve this goal, these farmers would need systematic training and access to supporting technologies (equipment, machinery, tools, and software) on dairy technology, nutrition, management, selection and mating practices, and data recording.

Decision making on sire selection

Decision making on sire selection was not important for any trait ($p>0.05$). Thus, the pattern of differences among farmers who selected sires by themselves, with help from government officials, and with help from organization staff was similar for all traits. Farmers that selected sires by themselves had LSM of 4,274.80±145.51 kg for MYF (Figure 7A), 330.23±7.33 kg for MYC (Figure 7B), 56,053.00±1,824.64 baht for MRF (Figure 7C), and 4,295.41±104.59 baht for MRC (Figure 7D). Farmers that selected sires with help from government officials had LSM of 4,069.02±415.99 kg for MYF, 323.63±19.56 kg for MYC, 54,420.00±5,190.93 baht for MRF, and 4,152.95±278.72 baht for MRC. Farmers that selected sires with help from organization staff had LSM of 4,316.14±237.94 kg for MYF, 337.73±11.45 kg for MYC, 57,148.00±2,973.79 baht for MRF, and 4,354.76±163.24 baht for MRC. The highest LSM for all traits was that of farmers that selected sires with help from organization staff, followed by farmers that made decisions by themselves and lastly farmers that made decisions with help from government officials.

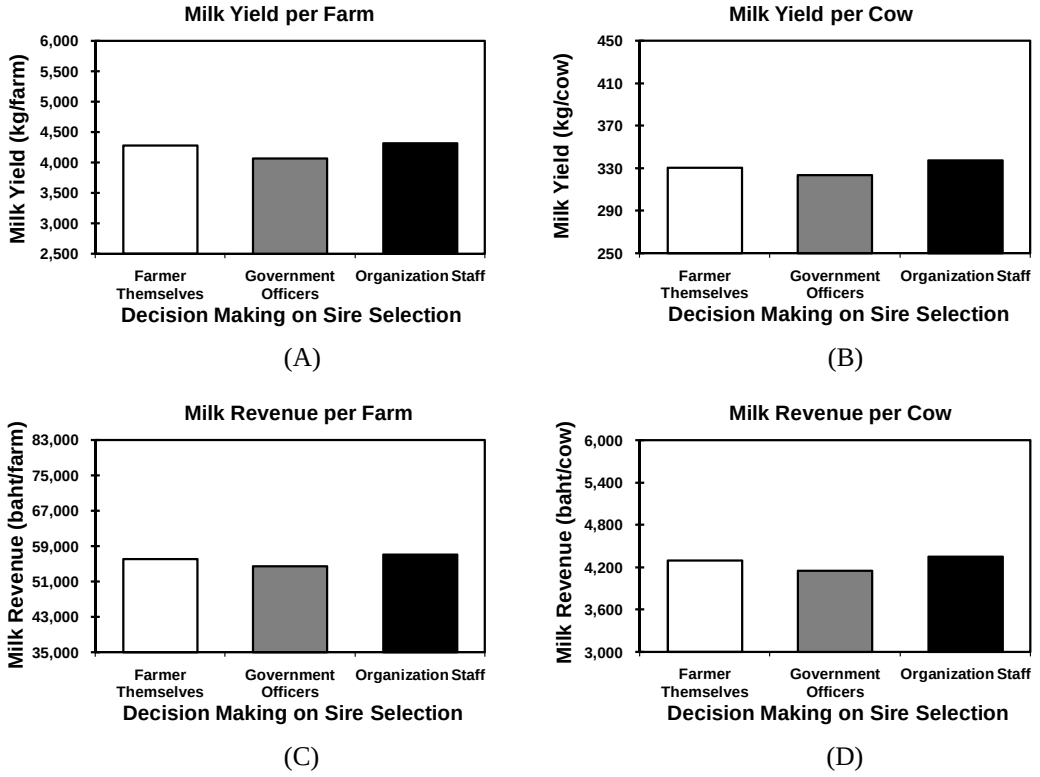


Figure 7. Least squares means for monthly milk yield per farm (A), milk yield per cow (B), milk revenue per farm (C), and milk revenue per cow (D) by category of decision making on sire selection. No significant differences existed among decision making categories ($p>0.05$).

Although differences among categories of decision making for sire selection were non-significant, it may be worthwhile to suggest a possible explanation for differences among LSM. Differences in LSM among the three decision making categories could be due to accuracy of decisions. The private organization hired people to provide services (artificial insemination, health care, farm monitoring) and support their members. Support personnel had frequent visits to each individual farm and also gathered information. Thus, sire selection decisions made by farmers supported by organization staff appeared to have been more accurate than decisions made by farmers in the other two categories. In contrast, government officials provided various services (disease control, extension, and artificial insemination services) to all dairy farmers in a region, regardless of their membership in any organization. Thus, government officials may not have enough specific information from individual farmers (pedigree, production traits, and reproduction traits of the individual animals) or, as indicated by Srinoy et al. (1999), they may not have provided a particular service. Consequently, government officials may frequently not be able to give accurate suggestions to solve specific problems in individual farms.

Farmers that made decisions on sire selection by themselves constituted 82% of all farmers in this population. They had higher LSM for all traits than farmers that made decisions with help from government officials, but lower LSM than farmers that made decisions with help from organization staff. A program of training and support on how to choose the most suitable bulls for their farms that targets farmers that make decisions by themselves seems advisable to improve accuracy of sire selection in the largest group of farmers in Thailand. This program would need to provide these farmers with accurate genetic predictions for individual bulls (estimated breeding values, and assisted markers) for appropriate sire selection (Rhone et al., 2008a; 2008c; Koonawootrittriron et al., 2009).

CONCLUSIONS

Experience and type of labor were important for all traits (MYF, MYC, MRF, and MRC; $p<0.05$). Education of farmers was important only for MYC and MRC ($p<0.05$). Record keeping was important only for MYF and MRF ($p<0.05$). Decision making on sire selection was not important for any trait. Most farms were small (55%) and the vast majority of farmers had primary school or no school education (65%), kept no records (78%), used their family members for dairy work (85%), and made decisions on sire selection by themselves (82%). These findings suggested that farmers may have limitations in their ability to understand new technology and to acquire new knowledge for improving dairy production and profitability. To overcome these limitations, dairy farmers in Central Thailand need a program that includes systematic training and continuous support to improve farm milk production and revenues in a sustainable manner. Furthermore, if the structure in Central Thailand were similar to the rest of the country, then a national program of this kind would seem advisable.

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