Chapter 8

Effects of Environmental Factors on Milk Yield, Lactation Length and Dry Period in Tunisian Holstein Cows

Naceur M'hamdi, Mahdi Bouallegue, Saoussen Frouja, Yosra Ressaissi, Satinder Kaur Brar and Mohamed Ben Hamouda

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1. Introduction

Management, nutrition, lactation turn or the age, year and season in which lactation started are the leading environmental factors affecting lactation performance in cattle. Beside these factors, the persistency level of the highest milk production period reached on lactation is a significant factor [1]. Also, lactation performance in dairy cattle depends upon genetic and environmental factors. Genetic background, climate, diseases, feeding, year and season of calving have been reported to affect milk production, lactation length and dry period [2, 3]. Breed, age, stage of lactation, parity and milking frequency also influence performance production [2, 3]. Holstein cows were considered the most dairy cows in the World. As number of Holstein cows in Tunisia is more than other breeds, breeding of Holstein cows is very important. Milk yield and duration of lactation have marked effects on dairy economy [4, 5]. The persistency level of lactation milk production can be defined as the ability of keeping a high daily milk flow during lactation, in the milk productivity of lactation's first period's persistency level or the rest of the lactation as a measure of lactation curve diagram, the highest period productivity of the continuation level during lactation, continuation level of the highest productivity and after reaching the highest productivity the rate of decreasing seen on milk production in time. Milk yield is the most important single determinant of profit for the dairy cow. Moreover, effects of lactation number, age, and season and year of calving on milk yield and lactation length are well known. In addition, in breeding of dairy cows, the most important aims are to obtain a calf in a year and high milk yield from cows. To obtain a calf in a year from cows depends on some parameters of ideal limits (60 days dry period, 305 days lactation duration etc.). However, profitable breeding could be achieved by keeping lactation

duration, dry period and service period between optimal limits [6, 7]. The yields of farm animals are the result of the combined effects of genotype and environmental conditions. In order to increase the yield level, it is necessary to optimize the environmental conditions and to improve the genetic structure of the animals. In order to enhance productivity of a dairy animal, it is necessary to develop an understanding of the factors affecting its milk production. Environmental factors can be classified as factors with measurable effects (age, year, season, milking frequency, etc.) and factors with immeasurable effects (infectious diseases, parasitic infestations, etc.). The measurable effects can be determined and used in the management of the farm [8]. Environmental factors affecting variability in daily milk yield are widely documented in dairy cattle [9-11]. The 305 days milk yield of Holstein cows was 5905 kg in Tunisia [12], 5353 kg in Morocco [13], and between 4597 and 6464 kg in Turkey [14- 16]. Environmental factors such as year of calving, season of calving and age at calving affect productivity [17]. Many researchers [6, 14] reported that the effect of calving season on 305 days milk yield was as significant and indicated that milk yield was higher in autumn and winter. Unlike, Bilgiç and Aliç [16] and Pelister et al. [18] reported that effect of calving season on 305 days milk yield was non-significant. Although, effect of lactation number on 305-days milk yield was reported [14, 15, 19] as significant. Opposing, Koçak et al. [6] and Bilgiç and Aliç [16] reported a non-significant effect of lactation number on 305 days milk yield. Effects of calving age on 305 days milk yield have been reported as significant [18, 20]. The lactation duration of Holstein cows was between 284.7 and 333.9 days in previous studies [14, 16, 21, 22]. The effect of calving season on lactation duration was reported as non-significant [6, 16, 18]. The effect of lactation number on lactation duration was reported as non-significant [14, 16, 19]. However, the effect of calving age on lactation duration was reported as significant [15, 18]. Zambrano et al. [23] reported that the effect of calving year on lactation duration was significant. The dry period of Holstein cows was between 73.34 and 82.1 days [14, 15, 22]. Koçak et al. [6] and Pelister et al. [18] reported a non-significant effect of calving season on dry period. However, Erdem et al. [14] stated a significant effect of age at calving on lactation duration. Similarly, the effect of lactation number on dry period was reported as non-significant [14, 15]. On the other hand, the effect of calving age on lactation duration was stated as significant [19]. Effects of age at calving on dry period have been reported as significant [18]. Many researchers [14, 15, 23] were found that effect of calving year on all milk yield traits (305 days milk yield, lactation duration, dry period) was significant. Inci et al. [15] reported that effects of calving year on 305 days milk yield and lactation duration were significant but non-significant on dry period. The present research work was designed to investigate non-genetics factors affecting milk yield, lactation length and dry period of Holstein cows raised under Tunisian conditions.

2. Materials and methods

The data used in the present study were taken from the Tunisian Livestock and Pasture Office (OEP). 260.241 test-day records of 5649 Holstein cows from Tunisian milk control

data were analysed. Data from lactations records of cows having their first calving between 1996 and 2003 were used. To evaluate the significant effects of calving year, season of calving, lactation number, and age at calving on different milk yield traits, eight groups for calving year were formed, between 1996 and 2003, three age groups of calving age (1) 2–4, (2) 5–6, and (3) 7 or older, four calving seasons were established; winter (December, January and February), spring (March, April and May), summer (June, July, August), and autumn (September, October and November) and five groups for parity. The 305 days milk yield was estimated from test milk yields collected once a month during all lactation periods [8, 24]. Lactations with less than five tests were not used in calculation. Milk yields were standardized to 305 days by using adjustment factors estimated by Çilek [25]. Environmental factors, which influenced lactation milk yield, lactation duration and dry period were investigated. Simple means and standard errors for the traits studied were estimated using SAS 9.13. The General Linear Model (GLM) was utilized for variance analyses of milk yield traits. Duncan's multiple range test (DMRT) was used for multiple comparisons of each trait.

The statistical model was as follows:

$$Y_{ijkl} = \mu + L_i + S_j + CY_k + AC_l + e_{ijklm}$$

Where,

Y_{ijkl} = Observed trait at lactation number i, calving season j, calving year k and group of age l

μ = Population mean for each trait,

L_i = Effects of lactation number (i = 1, 2, 3, 4, 5),

S_j = Seasonal effects (j = spring, summer, autumn and winter),

CY_k= Effect of calving year (k = years between 1996 and 2003),

ACl = Effect of group of age at calving (l= 1, 2 and 3),

e_{ijklm} = Random sampling error

3. Results

The lactation performance of dairy cattle is usually measured by determining the total milk yield per lactation or per year, average daily milk yield, lactation length, lactation persistency, and milk composition. The least squares means along with their standard errors for different traits analysed are presented in table 1. The overall average 305-days milk yield was 5807.83±78.27 kg, ranging between 2271 and 7013. Average lactation length and dry period were estimated to be as 309.60±7.01 and 97.17±3.28 days, respectively when minimums were forced to be at least 127 and 11 days and when 356 and 213 days as maximums values. Average age at first calving was 1092.3 ± 196.8 days (range, 646–1588 days). The effect of year and season of calving and parity was significant (P<0.01) on milk traits. Effects of all factors (calving year, calving age, parity and calving season) on 305-days milk yield were significant (P<0.001).

Trait	Records	Means	SD	Minima	Maxima
305-days Milk yield (kg)	2147	5807.83	78.27	2271.53	7013.80
Lactation length (days)	1789	309.60	7.01	127.56	356.53
Dry period (days)	1789	97.17	3.28	11	213.71

Table 1. Records, means, standard deviations, minima and maxima of variation for milk yield, lactation length and dry period of Holstein cows

3.1. Sources of variation

The major sources of variation in milk production, lactation length and dry period are genotype, environment and the interaction between the two. The influence of environmental factors on dairy production has been well documented.

3.1.1. Effect of calving year

Year of calving significantly influenced MY (P<0.001). The variation in milk yield from one year to other (Table 2) could be attributed to changes in herd size, age of the animals and good management practices introduced from year to another. The lowest 305 days milk yield (4879±117.89) was seen in 1998 years, the highest milk yield (6251±185.72 kg) was seen in 2003. Furthermore, the effects of calving year on lactation duration were statistically significant (P<0.05). Effects calving year on dry period were statistically significant (P<0.001). The dry period was lowest (96.57±5.57 days) in 2002 and highest (113.29±3.78 days) in 1996. Year wise means indicated that there was an increasing trend in lactation length from 1996 to 2003.

Calving year	305 days milk yield (kg)		Lactation length (day)		Dry period (day)	
	n	Mean±SE	n	Mean±SE	n	Mean±SE
1996	1147	5223±118.74b	1147	269.9±7.56a	1086	113.29±3.78a
1997	1158	5396±127.43a	1158	273.3±9.78a	978	110.37±4.56a
1998	2151	4879±117.89c	2151	277.6±7.67ab	1113	107.43±4.28ab
1999	3146	5352±123.91ab	3146	281.5±7.23b	1275	103.73±5.36bc
2000	4183	5609±127.83ad	4183	288.3±6.47b	1256	101.85±5.78c
2001	4728	6051±156.25d	4728	292.6±8.46bc	1317	99.47±6.32dc
2002	4689	6125±158.36d	4689	312.7±5.13c	1328	96.57±5.57d
2003	3879	6251±185.72d	3879	322.78±6.44c	1278	98.23±4.86d

a-d: differences between groups with same letter in the same column are non-significant, differences with different letter are significant (p<0.05).

Table 2. Least square means of milk yield traits by calving year

3.1.2. Effect of calving season

The least squares analysis revealed that 305 days milk yield was significantly (P<0.001) affected by season of calving (table 3). The present results suggested that milk yield was sensitive to seasonal variation. The effect of calving season on milk yield was significant

and milk yield was high (5827±69.23) in cows calving in winter. However, the effect of calving season on lactation duration was significant (P<0.001), but non-significant (P>0.05) on dry period. Then, season of calving affected both the lactation length and milk yield. As shown in table 3, least squares mean was higher for automn calvers (307.6±4.57 days) as compared to spring calvers (296.7±3.99 days). Although, summer and winter calvers have similar lactation length (301.4±4.12 and 303.7±4.28 days) but winter calvers have the highest milk yield (5827±63.17 kg). Milk yield on the other hand had the opposite trend. Summer calvers produced 614 kg less milk (5213 vs. 5827 kg) as compared to winter calvers.

Calving season	305- days milk yield (kg)		Lactation length (day)		Dry period (day)	
	n	Mean±SE	n	Mean±SE	n	Mean±SE
Spring	1235	5608±62.36ab	1235	296.7±3.99b	978	104.29±2.78a
Summer	1117	5213±73.17b	1117	301.4±4.12ab	1109	98.23±3.12a
Autumn	1227	5713±69.23ab	1227	307.6±4.57a	1089	96.48±3.28a
Winter	1347	5827±63.17a	1347	303.7±4.28ab	1117	87.56±2.97a

a, b, c: differences between groups with same letter in the same column are non-significant, differences with different letter are significant (p<0.05).

Table 3. Least square means of milk yield traits by calving season

3.1.3. Effect of age at calving

Total 305 days milk yields were lowest in 2-4 years of age at 5312 kg and highest in 7 years of age at 5611 kg. However, the effects of age at calving on lactation length were non-significant (P>0.05). Dry period increased with increase of age at calving. The lowest dry period was found in 2-4 years old age at 83.37 days and highest in 7 years old age at 99.71 days. The dry period was above the ideal value in all years. In order to make animals more profitable, it is essential they were made pregnant as soon as possible during the service period in order to shorten the dry period (Table 4).

Age at calving	305 days milk yield (kg)		Lactation length (day)		Dry period (day)	
	n	**Mean±SE**	**n**	**Mean±SE**	**n**	**Mean±SE**
1	1256	5312.54±78.95a	1256	307.56±4.78a	1127	83.37±3.27a
2	1147	5517.23±72.36ab	1147	303.47±5.12a	1217	87.12±3.54ab
3	1378	5611.17±79.27b	1378	299.78±4.56a	1236	99.71±3.31b

a, b: differences between groups with same letter in the same column are non-significant, differences with different letter are significant (p<0.05).

Table 4. Least square means of milk yield traits by group of calving age

3.1.4. Effect of parity

The effects of parity on lactation duration were statistically significant (P<0.001). Lactation duration was shortest in lactation 5 at 297.8±3.04 days and longest in lactation 4 at 317.5±4.17 days. Lactation duration decreased with increase of lactation number. Effects of parity on

dry period were statistically significant (P<0.001). Dry period was longest in 5th lactation at 113.28±3.25 days and shortest in 3rd lactation at 87.23±2.17 days (Table 5).

Lactation number	305 days milk yield (kg)		Lactation length (day)		Dry period (day)	
	n	Mean±SE	n	Mean±SE	n	Mean±SE
1	1457	5412.27±52.41a	1457	311.7±3.12a	1123	93.14±2.34a
2	1353	5721.35±54.74b	1353	307.1±2.78ab	1099	89.27±2.41b
3	1246	5614.23±47.13bc	1246	303.3±3.27c	987	87.23±2.17b
4	1127	5417.58±46.51a	1127	317.5±4.17b	956	95.16±3.04a
5	978	5123.47±48.45c	978	297.8±3.04ac	979	113.28±3.25c

a, b, c: differences between groups with same letter in the same column are non-significant, differences with different letter are significant (p<0.05).

Table 5. Least square means of milk yield traits by parity

4. Discussion

In this study, means of 305 days milk yield was 5807.83±78.27 kg. The findings of present study were in accordance with those of Ajili et al. [12], Boujenane [13], Erdem et al. [14], Inci et al. [15], Bilgiç & Aliç [16], Duru & Tuncel [21] and Kaya et al. [22]. As reported previously [7, 20, 26], the effect of calving season on milk yield was significant and milk yield was the highest in cows calving in winter. Similar finding have been reported by Javed et al. [27] and Tekerli et al. [28] in Holstein Friesian cows. Thorpe et al. [29] showed the effects of season of calving on production performance of dairy cattle in Kenya. Cows calving in winter have high milk yields, due probably to good feeding levels in the first 3 or 4 months of lactation. On the other hand, cows calving in summer have low milk yields due to their being subject to high environmental temperatures in the first 3 or 4 months of lactation. On the contrary many workers [30 - 32] observed that the season of calving had a non-significant effect on lactation milk yield in Holstein Friesian cows.

Analysis of variance revealed that 305-days milk yield is significantly (P<0.05) affected by age at calving. The result is closely in accordance with the results of Kaya et al. [22] and Catillo et al. [33]. The lowest milk yield was obtained from cows calving at 2 years of age and the highest from those calving at 7 years of age. The negative effect of early calving on milk yield could have been due to different factors, such as higher body weight gain before puberty. Milk yield decreased after 7 years of age. As reported in the literature [7, 20], this confirms that milk yield increases with age up to maturity and decreases thereafter.

305-days milk yield differed significantly (P<0.05) with calving year (Table 2). The lowest milk yield was obtained in 1998. After 1998, milk yield increased up to 2003. The reasons for this increase could be the use of bulls with high genetic capacity, selection for milk yield and culling in the herd and especially improvement in management and feeding conditions. The variation in milk yield observed in different years reflected the level of

management as well as environmental effects. Between 1996 and 2001, short lactation duration and consequently low milk yield may result from the deficiency of attention and feeding conditions. The significant effect of year of calving productive performance of dairy cows could be attributed to the changes in feeding and managerial systems and environmental conditions which occurred from year to another as well as to differences between years in the quantity and quality of forage available. 305-days milk yield differed significantly ($P<0.05$) with lactation order (Table 5). The 305-days milk yield in second lactation was significantly higher than in first lactation. This result is consistent with Munim et al. [34] who found significant ($P<0.05$) effect of parity on milk yield. Nevertheless, the result differed from that of Habib et al. [35] who found non-significant ($P>0.05$) effect of lactation number on milk yield. The significant effect of parity on productive performance may be due to the changes in managerial systems and environmental conditions among parties. The average lactation length calculated in this study was 309.6 days. This was very close to the ideal value (305 days). This length of lactation was longer than results reported by Sattar et al. [36] and Alim [37] who reported a lactation length of 293 ± 3 and 291.86 ± 6.55 days in Friesian cows in Libya and Pakistan, respectively. The lactation duration of Holstein cows was between 284.7 and 333.9 days in previous studies [14-16, 18, 21, 22]. The shorter lactation duration is 127.56 days it may be related to incomplete lactations when data were collected. Lactation duration decreased with increase of lactation number. Short lactation duration in the oldest cows (5th lactation number) may be related to incomplete lactations because of culling.

The average dry period was 97.7±2.25 days. Dry period was higher than the ideal value (80 days) but shorter than funding of Sattar et al. [36] who reported a longer (224.99 days) dry period. However, the dry period increased with calving age, as a result of increase of milk yield level with age in the herd. It can be said that if milk yield increases with calving age, dry period would decrease. Effect of calving year on all milk yield traits was significant. Differences among years may be related to management. It can be said that differences of management among years was the most important factor affecting milk yield traits.

Dairy cows are usually dried-off for two months prior to the next calving. This rest period is necessary to maximize milk production in subsequent lactation. It was reported that the dry period is required for the renewal of the udder glandular tissue [38, 39]. Nevertheless, the optimal dry period was established as 60 days. A significant increase in milk yield of the dairy cows caused a new attention in creating the optimum dry period [40]. Two months were accepted as a sufficient dry period for high-productive cows [41]. A research done in Poland by Borkowska et al. [42] and Winnicki et al. [43] indicated that in practice the dry period is extended or excessively shortened, which leads to a reduction in milk production as compared to the recommended optimum. Milk yield is usually reduced when the dry period is less than 40-60 days (25-40% less milk). Dry period longer than 60 days in length does not result in a significant increase in milk production. Long dry

periods decrease the average annual production of the cow by extending the calving interval beyond the normal 13-14 month interval and causing a decrease in the lifetime production of the dairy cow.

5. Conclusion

In this study, there was increase of milk yield level according to previous research [16]. This may result from improvement in breeding, feeding and management conditions (selection for milk yield and culling in the herd etc.). Although, lactation duration was found almost at ideal value, dry period was estimated as higher than the ideal value. In order to make animals more profitable, it is essential to make them be pregnant as soon as possible during the service period in order to shorten the dry period. It can be concluded that Holstein cattle is raised successfully for milk yield under Tunisian environmental conditions. It is concluded that milk yield and lactation length are affected by year and season of calving. Adjusted milk yield (adjusted for lactation length) and lactation length are affected by year into season of calving interaction but actual milk yield is not affected by year by season of calving interaction. Age within parity, also, affected lactation length and milk yield. Negative phenotypic trend in milk yield is alarming and needs further investigations.

Author details

Naceur M'hamdi and Saoussen Frouja
Department of Animal Sciences. Higher Institute of Agronomy of Chott-Mariem, Sousse, Tunisia

Mahdi Bouallegue
Faculty of Mathematical, Physical and Natural Sciences of Tunis, Tunis, Tunisia

Yosra Ressaissi
National Institute of Agronomy of Tunis, Tunisia

Satinder Kaur Brar
National Institute for Scientific Research, Quebec, Canada

Mohamed Ben Hamouda
Institution of Research and Agriculture Higher Education (IRESA), Ministry of Agriculture, Tunisia

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