



Study of effect of various genetic and non-genetic factors on milk yield in Frieswal cattle

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ABSTRACT

The present study was carried out on data of 3,425 Frieswal cattle (Holstein Friesian × Sahiwal cattle) maintained at Military Farm, Pimpri, Pune, Maharashtra. Total 9,094 lactation records were collected from 3,425 cows born to 239 sires. The data were analyzed using SAS software. The collected data were normalized and utilized for studying effect of genetic and non-genetic factors on milk yield. The *PROC GLM* procedures of SAS were used to quantify the effect of non-genetic factors on milk yield. The non-genetic factors considered for the present study were period of calving, season of calving and parity whereas, the covariate considered was age at first calving (AFC). The estimated overall least squares mean of lactation milk yield was observed as 3188.65 ± 10.93 kg in Frieswal cattle. The effect of period of calving, and parity was highly significant on lactation milk yield while the season of calving had significantly affected the milk yield. The age of first calving as a covariate had highly significant effect on milk yield. Amongst the genetic factors, the effect of sire was considered and found to be highly significant on lactation milk yield.

Keywords: Frieswal cattle, Genetic and non-genetic factors, Lactation milk yield

India is an agricultural country and over 70% of the rural households depend on agriculture sector for their livelihood. It is an important sector of the Indian economy as it contributed about 20% to the total GDP first time in the last 17 years during 2020-21 (Economic survey of India 2020-2021). Animal husbandry is the allied sector of agriculture and serve as source of livelihood and employment to most of the rural population. Dairy farming is an important sector amongst the animal husbandry. India has a total livestock population of 535.78 million including 192.49 million cattle and 109.85 million buffaloes. The cattle population in India is more than 20% while buffalo population is more than 50% of the world's population (20th Livestock Census of India 2019). India ranks first in the world with annual milk production of 209 million metric tonnes in 2021 and the per capita availability of milk in India increased from 406 g per day in 2020 to 427 g per day in 2021. However, the average milk production per animal is still lower as compared to global average. The low genetic potential of animals is further aggravated by the poor managerial practices, inadequate nutrition, unorganized veterinary services, etc. Milk production is the complex trait affected by various genetic and non-genetic factors.

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The net genetic progress and effectiveness of the selection program may be measured when selection is made for more than one trait. However, the non-genetic factors suppress the animal's genetic potential and create biasness while selecting the animal for high milk production. These non-genetic factors include direct climate effect, managerial problems, nutrition, age, year and season, etc. The targeted improvement towards these factors may be helpful substantially to increase the performance in dairy cattle. Considering this fact, the present study was designed to study the effect of various genetic and non-genetic factors on milk production in Frieswal cattle.

MATERIALS AND METHODS

Source and collection of data: The data for the present study were collected on Frieswal cattle (Holstein Friesian × Sahiwal cattle) maintained at Military Dairy Farm, Pimpri, Pune, Maharashtra, India for the period of 1981 to 2018. A total of 9,094 lactation records belonging to 3,425 Frieswal cows born to 239 sires were recorded. The data available from various records, viz. pedigree register, history sheets, lactation register, dry cow register and disposal register were collected and compiled. The information was collected on animal ID, name, sire ID and name, dam ID and name along with date of birth, date of calving, date of drying and lactation data.

Location and climatic condition of the farm: The military farm is located at Pimpri Chinchwad, Pune city of Maharashtra at latitude 18.6121°N and longitude

73.8097°E. It comes under tropical wet and dry climate with average temperatures ranging between 21.7°C to 28°C. The maximum temperature ranging from 25.4°C to 37°C during typical summer months (Feb-May) while minimum temperature ranging from 15.1°C in January to 24.2°C in October. Pune city experiences extreme seasonal variation in monthly rainfall. The average rainfall throughout the year was recorded as 100 mm (3.92 inches) with average monsoon rainfall (June–September) of 262 mm (10.27 inches). There were extreme variations in perceived humidity throughout the year, i.e. 35% in March to 88% in July and August (climate– data.org, <https://en.climate-data.org/asia/india/maharashtra/pune-31/>).

Management practices: The calves and non-lactating heifers were reared under loose housing as per the age groups and different physiological status whereas, lactating cows were housed in tail to tail system with open paddocks. The separate open paddocks with shed under loose housing system were provided separately for dry, lactating and advanced pregnant cows. The nutritional requirement is met through balanced combination of green and dry fodder along with supplementation of concentrate mixture. Breeding data were maintained on manual sheets which include the history and pedigree sheet.

Ear tagging of the animals were done for identification and the record of each animal pertaining to the name, breed, dam, sire and milk yield was displayed on separate display board for each animal. The immunization schedule (FMD, Brucellosis and Hemorrhagic Septicemia), regular health checkup, production and reproduction status recording were followed strictly and monitored by veterinary officer. Total milk yield was obtained from daily milk register wherein morning and evening milk yield for each animal was recorded separately along with monthly milk yield at the end of each month. High yielding cows (above 35 kg/day) were milked thrice a day and fed with extra production ration. Heat detection was carried out daily during the morning hours and the cows were examined for pregnancy after 45 to 65 days of insemination.

Data standardization: The cows which were affected with disease or debilitated or died before completion of first three lactations and the sires with less than five progenies were omitted from the study. Further, the data were standardized by removing the records for the cows having AFC above 1250 days, lactation length below 100 days and above 365 days, lactation milk yield below 1000 kg and inter-calving period below 250 days.

Descriptive analysis: The data were tested for normal distribution using *PROC UNIVARIATE*, of SAS9.13. The data were also transformed into log and square root transformation to check whether there are any changes in the distribution of data. The descriptive statistics, viz. number of observations, minimum, maximum, mean, standard errors and coefficient of variation (CV) were estimated using *PROC MEAN* procedure of SAS 9.13 for different traits.

Effect of non-genetic factors on milk yield: In the present

study, period of calving, season of calving and parity were considered as non-genetic factors.

The data were grouped into four periods and classification of periods was based on distribution of sires and dams, records available per sire and dam. The data was collected from 1983-2018. The period one was extended from 1983 to 2003 because very few records were available in that period. The subsequent periods were uniformly grouped with the records of five years each, i.e. 2004 to 2008 (P_2), 2009 to 2013 (P_3) and 2014 to 2018 (P_4). The season-wise classification was done as per the climatic conditions prevailing at the farm, the monthly average temperature, minimum temperature, maximum temperature, precipitation (rainfall), humidity and rainy days throughout the year. The winter season was from October to January, summer from February to May and rainy from June to September. The total parities were numbered from first to the last lactation and the effect of lactation order on lactation milk yield was studied in Frieswal cattle.

The normalized data were utilized to find out the effect of above non-genetic factors on the lactation milk yield. The PROC GLM procedures of SAS were used to quantify the effect of period, season and parity on milk yield. The interaction effect of all the non-genetic factors up to two and three levels considering the period, season and lactation were estimated on the milk yield. The means of different levels within a class factor were compared using DMRT. All non-genetic effects were considered as fixed effects.

The effects of genetic and non-genetic factors on various traits were estimated by using PROC GLM procedures of SAS. The model used for estimating the effect of non-genetic factors on milk yield was:

$$Y_{ijkl} = \mu + b(AFC_{ijkl} - AFC) + S_i + P_j + A_k + e_{ijkl}$$

Where, Y_{ijkl} , observation on the i^{th} individual in i^{th} season, j^{th} period and k^{th} parity; μ , overall population mean; $b(AFC_{ijkl} - AFC)$, regression of the trait on AFC; S_i , effect of i^{th} season where $i=1, 2$ and 3 ; P_j , effect of j^{th} period where $j=1, 2, \dots, 4$; A_k , effect of k^{th} parity $k=1, 2, \dots, 11$; e_{ijkl} , random error, NID $(0, \sigma^2e)$.

RESULTS AND DISCUSSION

Effect of period of calving: The effect of period of calving was highly significant (<0.001) on lactation milk yield (Table 1). The average milk of second period (3312.67 ± 26.77 kg) was highest followed by the fourth period (3241.14 ± 18.74 kg). The mean milk yield of the first period (3055.73 ± 27.74 kg) was the lowest among all. The lower lactation milk yield during the first period in the present study might be due to the fact that the breed development program was underway by crossing the Sahiwal with Holstein Friesian and the desired breed stability was not achieved. The better performance of the cows calved in period two, three and four may be ascribed to the stabilization of breed and improvised managerial practices in the farm as the period advanced. Ali *et al.* (2002)

Table 1. Analysis of variance for the effect of various non-genetic factors on lactation milk yield

Source	DF	Type III SS	Mean sum of square
<i>Non genetic factors (ANOVA 1)</i>			
AFC	1	25464418.2	25464418.2**
Period	3	35591443.8	11863814.6**
Season	2	15155279.8	7577639.9*
Lac	10	926726547.1	92672654.7**
Period*Lac	30	115910302.2	3863676.7**
<i>Genetic factor (ANOVA 2)</i>			
Sire	227	837021681	3687320**

*, $P \leq 0.05$ (significant) and **, $P \leq 0.01$ (highly significant).

also reported significantly lower first lactation milk yield in first period in Jersey and HF crossbred cows. The variation from one period to other may also be attributed to the changes in herd size, age of the animal, stage of lactation, changes in the climatic conditions, feeding practices introduced from year to year and quality as well as herd genetic levels are some of the other factors influencing the milk yield during different periods. The period-lactation interaction was also highly significant for lactation milk yield.

The reviewed literature suggests differing observations about the effect of the period of calving on lactation yield. Significant impact of a period of calving on lactation milk yield was observed by Chopade *et al.* (2002) in crossbred cattle, Bajwa *et al.* (2004) in Sahiwal cows, Latkar *et al.* (2009) in Gir and its Jersey and HF Crosses and Das *et al.* (2011) in crossbred dairy cows. Amimo *et al.* (2007) reported a highly significant effect of the period of calving on lactation milk yield. However, the non-significant effect of period of calving was observed by Verma and Thakur (2013) in Red Sindhi $\times$ Jersey crossbred cows and Kumar *et al.* (2016) in Ongole cows.

Effect of season of calving: In the present study, the effect of season of calving on milk yield was highly significant ($p < 0.001$) as shown in Table 1. The Duncan's Multiple Range Test (DMRT developed by David B. Duncan in 1955) results indicated no significant difference in the milk yield obtained in summer and winter however, both these seasons differs significantly from rainy season in the milk yield.

The least squares mean for milk yield of the cows calved during the rainy season was the lowest (3145.90 ± 20.87 kg). The average milk yield of cows calved during the summer (3203.23 ± 18.90 kg) and winter (3205.26 ± 17.47 kg) were statistically not different from one another. The lower milk yield in rainy season may be due to the variations in climate and quality of feeds and fodders available in different seasons. The animals which received good management could be expected to respond well by expressing better production potentiality. Moreover, the seasonal stress of extreme temperature and humidity may suppress production. However, in organized dairy farms especially the military farms like the present one, the

supply of quality feed and fodder is always ensured. The appropriate managerial practices may help to overcome the seasonal impact on the milk yield. Bajwa *et al.* (2004) in Sahiwal cows, Wondifraw *et al.* (2013) in Holstein Friesian $\times$ Deoni cattle, Rehman *et al.* (2014) in Sahiwal cattle and Alex *et al.* (2017) in Frieswal cattle reported the significant effect of season of calving on lactation milk yield. Whereas, Ali *et al.* (2002) for first lactation milk yield in Jersey and HF crossbreds, Lakshmi *et al.* (2010) in Frieswal cows, Verma and Thakur (2013) in Red Sindhi $\times$ Jersey cattle and Kuchekar *et al.* (2021) in Phule Triveni cattle found contradictory results.

Effect of parity: The parity effect was highly significant (< 0.001) on milk yield (Table 1). It was observed that milk yield from third and fourth parity did not differ from each other. However, from fifth parity onwards, the milk yield declined gradually. The total milk yield was less in first parity (2885.71 ± 13.35 kg), and it showed an increasing trend in subsequent parities up to 3rd parity and gradually decreased from fifth parity onwards. The lesser milk yield in the first parity may be because the cows may not have grown fully and will spend a part of their energy on growth. The results also indicate that the Frieswal breed attains its full body size by the age 4.5 to 5 years and attains the peak milk production. The significant decline in the total average milk yield from the sixth parity onwards may be attributed to the increased age of the animal during which the degeneration of the reproductive organs takes place resulting into regression of milk yield. The effect of period-lactation was also highly significant on milk yield. The lower first parity milk yield was also observed by Wondifraw *et al.* (2013) in Holstein Friesian $\times$ Deoni cattle, Verma *et al.* (2016) in Sahiwal cattle and Santosa *et al.* (2019) for Dairy cattle. It was observed that the milk yield of third, fourth and fifth parity did not differ significantly from each other indicating that the peak milk yield in the Frieswal breed is reached in the third parity and is maintained till the fifth parity and then starts declining in further lactations. The significant influence of parity on lactation milk yield was also reported by Latkar *et al.* (2009) in Gir crossbreds and Beneberu *et al.* (2020) in pure Jersey cattle in Central Highland Ethiopia.

Effect of age at first calving: The least squares mean of AFC was 961.06 ± 1.51 days in Frieswal cattle. It has been found that the effect of AFC as a covariate was highly significant on lactation milk yield (Table 1). The AFC reflects the rate of growth of the female. The higher age at first service is indicative of delay in maturity which might be due to management lapses and environmental conditions. AFC is also important economic character, which influences the productive period and lifetime milk production (Vinothraj *et al.* 2016). Higher AFC reduces the economic value of the animals, due to the potentially decreased number of offspring produced in their lifetime. The results are in agreement with Mauren *et al.* (2014) in Holstein cows and Sawa *et al.* (2018) in dairy cows. However, the non-significant effect of AFC on lactation

milk yield was reported by Gatchearle *et al.* (2009) in HF × Deoni cattle. Teke and Murat (2013) also reported the non-significant effect of AFC on first lactation milk yield.

Effect of sire (genetic factor) on lactation milk yield: It was observed that the sire effect was highly significant (<0.001) on lactation milk yield (Table 1). It indicated that proper selection of sire can bring further genetic improvement in this trait. Lodhi *et al.* (2016) reported the highly significant effect of sire on lactation milk yield in crossbred cattle while Mishra (2016) and Choudhary *et al.* (2019) reported the highly significant effect of sire on first lactation milk yield in Tharparkar cattle. The significant effect of sire on lactation milk yield was also reported by Abbas *et al.* (2010), Kumar *et al.* (2016), Jadhav *et al.* (2019) and Kuchekar *et al.* (2021) in Sahiwal cattle, Ongole cattle, HF × Gir cattle and Phule Triveni cattle, respectively. However, Ali *et al.* (2002) and Kharat *et al.* (2008) reported the non-significant effect of sire on lactation milk yield in crossbred cows.

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