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Effects of Genetic and Non-Genetic Factors on First Lactation Traits and Replacement Rate and its Components in Crossbred Cattle

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Abstract

The present study was undertaken on 2,204 calvings of 390 crossbred cattle produced by 54 sires over 36 years. The FLTs showed that the notion due to sires were significant for AFC, FLMY-305, FLMY, FLL and FSP. The effects due to the period of calving were found significant for FLL and FSP. The effect due to the season of calving was found significant on FLMY-305. The effect due to the AFC was found highly significant ($P \leq 0.01$) for FLMY. The period notion on replacement rate and its parts viz., mortality, culling and replacement rate was found to be significant. The season of birth had significant effects on abnormal birth and replacement rate. About half (45.18percent) of total female calves were thrown off from the herd till they achieve AFC due to mortality and culling. Only 25.27 percent of the total pregnancies got into replacement heifers. It may be concluded that the performance of the crossbred herd understudy is comparable to other herds maintained elsewhere. Low to moderate heritability estimates obtained indicated the presence of adequate genetic variation within the herd and hence improvement in traits under study is possible by genetic selection along with managemental interventions.

Keywords: *Crossbred cattle. First lactation traits. Heritability. Postnatal mortality. Replacement rate*

Significance statement

Livestock research is now directed towards the investigation of crossbreeding to enhance genetic potential under different ecological niches for different objectives and to transmit a sizeable proportion of genes for milk production. This research study may be helpful in the future for rural development programs at the national and international levels. These research outcomes may serve as base information to the policy-making personnel and academicians for chalking out production strategy and upliftment of the rural economy.

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The present study revealed a highly significant effect of the AFC group on milk yield in crossbred cattle. Early calvers produced comparatively lower milk than the optimum calvers. The crossbred herd under the study seems to have moderate productivity but higher AFC, FSP, FDP, and FCI which can be reduced to optimum levels by selection and improved husbandry practices, as there exists huge variation in these traits within the herd. The heritability estimates for first lactation traits were observed low to medium which revealed that genetic variability in these traits was existing and these traits could be improved through genetic selection along with better feeding and management practices. Four pregnancies were required to produce one replacement heifer. Heifers born to younger dams have a higher replacement rate.

Introduction

Crossbreeding was started to enhance genetic potential under different ecological niches for different objectives and to transmit a sizeable proportion of genes for milk production. The basic theme was to confluence the milk yield potential of exotic breeds and stress sustainability and disease resistance capabilities of indigenous breeds within [1] the crossbred progenies, which would be desirable to maintain them under the tropical climatic conditions of India. Crossbreeding has been in practice for several decades as a tool to improve the production performance of native cattle breeds [2]. The appraisal of a breeding program can be done by estimating genetic changes over a period of time. The observed phenotypic change in the performance of a population for an economic trait per year consists of two components viz. genetic trend resulting from the change in mean breeding value due to selection and environmental trend due to cumulative change in various non-genetic factors. The estimates of the trends are essential because they permit a comparison of realized trends with expected ones in the experimental situation and an assessment of progress in a particular trait. The magnitude of genetic trends must be known for comparison of sires.

The evaluation of crossbred cattle in terms of the production performance traits along with the impact of certain non-genetic factors such as seasons, periods, and parities is essential to formulate breeding and selection strategies. For establishing an effective selection or breeding program, the knowledge of the genetic properties of production traits is of prime importance [3]. The genetic makeup of a population can be examined by considering into heritability and environmental factors affecting the performance of individuals in the herd [4]. The estimates of genetic parameters are very useful for an efficient selection program, which helps in predicting direct and correlated responses to selection. This ultimately helps in choosing a breeding system to be followed for future improvement and in estimating genetic gains. The replacement rate is the function of calf production traits, which are the prenatal calf losses by abortion and stillbirth, and postnatal mortality and culling of heifers from birth to reaching the age at first calving. Several environmental factors affect the replacement rate. The role of different non-genetic factors is of paramount importance to study the replacement rate and its components.

Therefore, the present investigation was planned to estimate the first lactation traits, heritability, replacement rate, and its components in crossbred cattle. It was done to evaluate the effects of genetic and non-genetic factors on these traits. The effects of the period, the season of calving, parity, and a genetic group of sire were also studied.

Materials and methods

The data were collected from history-cum-pedigree sheets of 390 crossbred cattle produced by 54 sires from their 2,204 calving records over 36 years (1981-2016) and maintained at the Instructional Dairy Farm (IDF), Pantnagar. The economic traits studied were: age at first calving (AFC), first lactation 305 days milk yield (FLMY-305), first lactation milk yield (FLMY), first lactation length (FLL), first service period (FSP), first dry period (FDP) and first calving interval (FCI). The least-squares technique [5] was employed to study the influence of season, period of calving, and AFC on first lactation traits. The duration of 36 years was divided into 6 periods of 6 years each *viz*. P1 (1981-1986), P2 (1987-1992), P3 (1993-1998), P4 (1999-2004), P5 (2005-2010) and P6 (2011-2016). Each year was further delineated into 3 seasons viz. S1 (April- June), S2 (July to October), S3 (November- March).

The different components of replacement rate were considered as losses due to prenatal mortality, frequency of male birth, and female calf mortality and culling from birth to reaching the age at first calving. Seasons, periods, and parity were considered to be different non-genetic factors affecting the replacement rate and its components. The sixth or greater parity of lactation was clubbed into one to get a sufficient number of observations. The effect of season and period of birth, as well as parity of calving, were taken as causal factors for calves replacing parental stock.

To study the effects of genetic groups of sire and different non-genetic factors such as periods, seasons, and AFC on various production and reproduction traits and to overcome the difficulty of disproportionate sub-class numbers and non-orthogonality, the data was analyzed by using least-squares analysis using the technique developed by Harvey [5]. The model used to analyze the data is given below:

$$Y_{ijklm} = \mu + P_i + S_j + M_k + A_l + e_{ijklm}$$

Where, Y_{ijklm} is an observation on the m^{th} progeny in the i^{th} period of j^{th} sire in k^{th} season and l^{th} age group;

μ= Overall mean; P_i = Effect of i^{th} period (i = 1……6); S_j= Random effect of j^{th} sire (j = 1…….54); M_k= Effect of k^{th} season (k = 1…3); A_l = Effect of l^{th} age group (l = 1…4); e_{ijkl}= Random error which is NID (0, σ_e^2).

Duncan's Multiple Range Test (DMRT) modified by Kramer [6] was used to make a pair-wise comparison among the means.

The heritability was estimated by the paternal half-sib correlation (Intra-sire correlation among daughters) method as described by Becker [7] was used as shown below:

$$Y_{ij} = \mu + S_i + e_{ij}$$

Where, Y_{ij}= Value of j^{th} progeny under i^{th} sire; μ= Overall mean; S_i= Effect of i^{th} sire; e_{ij}= Random error which is NID (0, σ_e^2).
T
he sire component of variance was estimated as

$$\sigma_s^2 = \frac{MSs}{R}$$

$$\sigma_e^2 = MS_e$$

Where, σ_s^2 = Sire component of variance; σ_e^2= Error component of variance; = Average number of progeny per sire

The following model was used to analyze the different components of the replacement rate concerning non-genetic factors: The analysis of variance was employed as per Tomar *et al.* [8] using the following model:

$$Y_{ijkl} = \mu + P_i + S_j + L_k + e_{ijkl}$$

Where, Y_{ijkl}= 1^{th} observation (replacement rate/its components) from a cow belonging to k^{th} paritry, calved in j^{th} season of i^{th} period; μ= overall mean; P_i = effect of i^{th} period of calving (i= 1,……6); S_j= effect of j^{th} season of calving (j= 1,……3); L_k = effect of k^{th} parity of lactation (j= 1, 2,……6); e_{ijkl} = random error specific to the particular observation.

Before the estimation of genetic parameters, the data were adjusted for different significant non-genetic factors (season/period of calving and parity effects).
The study was undertaken in compliance of the ethical standards and the study and experimental protocols were approved by the Institutional Animal Ethics Committee of Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Pantnagar, India. Moreover, the authors complied with the ARRIVE guidelines.

Results and Discussion

Effect of genetic and non-genetic factors on production and reproduction traits

The effect of sire had a highly significant effect on age at first calving (AFC). However, the period of birth and season of birth had non-significant effects on AFC (Table 1).

The effect of sire and season on first lactation 305-day milk yields (FLMY-305) were found significant in the present study ($P \leq 0.05$) in crossbred cattle. However, the period of calving and AFC had a non-significant effect on FLMY-305 (Table 1).

The effects of sire and AFC on first lactation milk yield (FLMY) were found highly significant ($P \leq 0.01$) (Table 1). The least squares mean for first lactation milk yield varied from 2224.02 ± 125.46 for 4^{th} group (AFC ≥ 1500 days) to 2631.04 ± 110.39 days in 3^{rd} group (AFC = 1301-1500 days) (Table 2). Indicating that as for as first lactation milk yield is concerned the optimum age at first calving range in 1301-1500 days but at the same time it will reduce the herd life and lifetime milk yield. However, the period of calving and the season of calving had a non-significant effect on FLMY (Table 1).

The effect of sire and the period of calving had a significant ($P \leq 0.05$) effect on the first lactation length (FLL) (Table 1). The least-squares mean for first lactation length varied from 308.57 ± 15.85 for Period 2 to 433.97 ± 40.79 day for Period 1 (Table 2). Suggesting that management in different periods influenced high lactation length vigorously. However, the effects of season and AFC on FLL were found non-significant (Table 1).

The effect of sire and the period of calving had a highly significant ($P \leq 0.01$) effect on first service period (FSP) in the present study (Table 1). However, the effects of the season of calving and AFC on FSP were found non-significant (Table 1).

The effect of sire, the period of calving, the season of calving and AFC had a non-significant effect on first dry period (FDP) and first calving interval (FCI) (Table 1).

Table 1: Analysis of variance (ANOVA) for first lactation production and reproduction traits of crossbred cattle ** P ≤ 0.01; * P ≤ 0.05

Source of Variation	DF	Mean Sum of Squares (MSS Values)						
		AFC	FLMY-305	FLMY	FLL	FSP	FDP	FCI
SIRE	53	768091.77**	649106.54*	782209.90**	6651.58*	2523.56**	7020.76	11053.98
PERIOD	5	125936.96	1094322.74	1300544.19	14801.25*	8044.68**	5702.01	11172.96
SEASON	2	440059.56	512017.51*	485836.52	3496.40	1574.55	4896.13	6110.41
AFC	3	236542.35	156324.30	323655.32**	1546.14	4362.12	8121.05	6286.60
ERROR	326	275386.21	484833.42	661950.56	6428.32	1472.34	7042.11	11891.45

Table 2. Least-squares means and standard errors for first lactation production and reproduction traits of crossbred cattle

Source	No. of obs.	AFC (days)	FL305DMY (kg)	FLMY (kg)	FLL (days)	FSP (days)	FDP (days)	FCI (days)
Overall mean	390	1277.75 ± 101.56	2673.48 ± 81.29	2746.23 ± 85.51	346.02 ± 7.44	245.91 ± 5.39	139.15 ± 7.53	489.01 ± 9.79
Season								
S1 (Summer)	69	1233.71 ± 117.34	2740.47 ± 112.64	2807.95 ± 124.95	352.78 ± 11.66	165.91 ± 5.39	148.22 ± 12.04	480.00 ± 15.65
S2 (Rainy)	96	1250.61 ± 111.70	2583.40 ± 102.05	2658.44 ± 111.85	338.85 ± 10.29	250.87 ± 6.37	135.46 ± 10.58	490.72 ± 13.75
S3 (Winter)	225	1348.93 ± 104.87	2696.57 ± 88.38	2772.31 ± 94.64	346.42 ± 8.45	244.00 ± 5.72	133.77 ± 8.61	496.31 ± 11.19
Period								
P1 (1981-1986)	8	1082.35 ± 281.49	2363.53 ± 357.69	2509.24 ± 415.90	433.97 ± 40.79	231.21 ± 19.94	87.01 ± 42.65	587.43 ± 55.42
P2 (1987-1992)	49	1376.97 ± 136.76	2351.59 ± 146.20	2368.74 ± 165.75	308.57 ± 15.85	258.52 ± 8.60	148.63 ± 16.47	461.67 ± 21.40
P3 (1993-1998)	62	1283.68 ± 136.38	2639.79 ± 145.58	2680.56 ± 165.01	351.47 ± 15.77	265.79 ± 8.56	130.65 ± 16.39	475.55 ± 21.30
P4 (1999-2004)	131	1290.74 ± 125.57	2682.06 ± 127.31	2734.46 ± 142.90	325.57 ± 13.51	265.76 ± 7.63	155.60 ± 14.00	480.77 ± 18.20
P5 (2005-2010)	129	1229.35 ± 130.88	2795.80 ± 136.40	2945.08 ± 153.92	323.71 ± 14.64	261.45 ± 8.09	156.22 ± 15.19	480.21 ± 19.75
P6 (2011-2016)	11	1403.45 ± 202.15	3208.12 ± 245.75	3239.32 ± 284.16	332.80 ± 27.72	192.70 ± 13.87	156.80 ± 28.94	448.44 ± 37.61
AFC								
A1 (≤1100)	141	_	2213.21 ± 74.32	2245.65 ± 112.36	320.49 ± 6.13	168.24 ±11.35	132.32 ±6.15	439.26 ±10.92
A2 (1101-1300)	112	_	2135.32 ± 80.42	2441.42 ± 99.01	318.85 ± 5.29	177.15 ± 11.56	127.13 ± 6.24	452.24 ± 7.96
A3 (1301-1500)	80	_	2225.24 ± 78.31	2631.04 ± 110.39	316.76 ± 6.54	174.57 ± 12.63	123.78 ± 6.38	457.54 ± 11.03
A4 (≥1500)	57	_	2336.01 ± 76.32	2224.02 ± 125.46	318.64 ± 7.47	185.10 ± 12.35	146.98 ± 8.32	468.47 ± 12.65

The sire effects are significant for all the traits under study except FDP and FCI indicating importance of genetic factor (sire) in influencing dairy character. Other non-genetic factors seem to have less influence on the traits under study.

Means and heritability estimates of first lactation production and reproduction traits

The overall least squares mean for AFC was found as 1277.75 ± 101.56 days (Table 2) and the heritability estimates of AFC were found to be 0.31 ± 0.14 (Table

3). The overall least squares mean for FLMY was found to be 2746.23 ± 85.51 kg (Table 2) and the heritability of FLMY was estimated as 0.27 ± 0.07 (Table 3). The overall least squares mean of FDP was observed as 139.15±7.53 days (Table 2) and the heritability estimate of FDP was found to be 0.24 ± 0.13 (Table 3). The overall least-squares mean of FCI was found as 489.01 ± 9.79 days (Table 2) and the heritability estimate of FCI was found to be 0.21 ± 0.09 (Table 3). The moderate value of heritability's AFC and FLMY suggested that there is a scope of improvement by selection with proper management practices. The moderate value of heritability for FDP and FCI indicates little influence of genetic factors on this trait. Hence, this trait can be improved only through managemental interventions.

The overall least squares mean for FLMY-305 was observed as 2673.48 ± 81.29 kg (Table 2) and the heritability of FLMY-305 was observed as 0.37 ± 0.12 (Table 3). The higher estimates of heritability for this trait indicated that this production trait is more influenced by additive genetic variability and, therefore, there is scope for improvement by selection with proper management practices.

The overall least squares mean for FLL was found to be 346.02 ± 7.44 days (Table 2). The heritability estimate of FLL was found to be 0.17 ± 0.08 (Table 3). The overall least-squares mean of FSP was found as 165.91 ± 5.39 days (2). The heritability estimate of FSP was found to be 0.17 ± 0.11 (Table 3). Since FLL and FSP traits are lowlily heritable it can be improved by employing family selection and better husbandry practices.

It may be seen from Table 2 that the crossbred herd under the study had higher AFC, FSP, FDP, and FCI which can be reduced to optimum levels by selection and improved husbandry practices, as there exists huge variation in these traits within the herd. The heritability estimates for most of traits are moderate indicating that there exists scope for improvement in these traits through genetic selection.

Table 3: Estimates of heritability of first lactation production and reproduction traits along with standard error in crossbred cattle

Traits	$h^2 \pm$ S.E.
Age at first calving (AFC)	0.31 ± 0.14
First lactation 305 day milk yield (FLMY-305)	0.37 ± 0.12
First lactation milk yield (FLMY)	0.27 ± 0.07
First lactation length (FLL)	0.17 ± 0.08
First service period (FSP)	0.17 ± 0.11
First dry period (FDP)	0.24 ± 0.13
First calving interval (FCI)	0.21 ± 0.09

Effect of non-genetic factors on replacement rate and its components

The seasons, period and parity had a significant (P ≤ 0.05) effect on pre-natal calf losses (abnormal births) in the present study (Table 4). The pre-natal calf losses due to abnormal births in crossbred cattle (Table 5) were observed to be varying from 8.32 percent in rainy season to 10.11 percent in the summer season. The pre-natal calf losses due to abnormal births in crossbred cattle (Table 5) were observed to be varying from 6.71 percent in Period VI to 10.79 percent in Period V, showing no pattern during different periods. Furthermore, the sudden increase in the incidence of pre-natal calf losses due to abnormal birth during II period could be due to some unpredicted managemental or environmental or health problems in the herd. The pre-natal calf losses due to abnormal births in crossbred cattle (Table 5) were observed to be varying from 5.34 percent (Parity 1) to 13.84 percent (Parity 4). There is no definite trend in pre-natal calf losses due to abnormal births among parity of calving on this trait.

The seasons had a non-significant effect on mortality rates in the present study (Table 4). The period and parity had a highly significant (P ≤ 0.01) effect on mortality rates in the present study (Table 4). The mortality rates in female calves in crossbred cattle (Table 5) were observed to be varying from 14.57 percent during Period IV to 21.62 percent during Period II. These significant period differences in mortality rates of female calves could be attributed to the managemental and environmental reasons. The mortality rates in female calves in crossbred cattle were observed to be varying from 6.07 percent (Parity 1) to 24.69 percent (Parity 6) (Table 5).

The seasons and parity had a non-significant effect on culling rates (Table 4). The period had highly significant (P ≤ 0.01) effect on culling rates (Table 4). The culling rate in female calves in crossbred cattle (Table 5) was observed to be varying from 21.95 percent in VI Period and 43.24 percent in II Period. The culling among the heifers is generally practiced as per the need of the herd and type of stock available for replacement. Therefore, generally culling is not practiced uniformly over different periods, which may result into significant variation in the culling of heifers.

The seasons, period and parity had a highly significant ($P \leq 0.01$) effect on replacement rates on a female calf basis (Table 4). The replacement rates on female calf basis were observed to be varying from 46.04 percent in summer season to 61.03 percent in rainy season (Table 5). The replacement rates on female calf basis were observed to be varying from 35.14 percent in II Period to 60.98 percent in VI Period (Table 5). The lowest replacement rate during second period could be due to the observed higher mortality and culling rates among female calves. The replacement rates on female calf basis were observed to be varying from 20.99 percent in sixth Parity to 78.50 percent in first Parity (Table 5). Though there was no definite trend between dam's parity and replacement rate.

The seasons had a significant ($P \leq 0.05$) effect on replacement rates on total pregnancies basis (Table 4). The replacement rates on female calf basis were observed to be varying from 19.84 percent in the summer season to 28.60 percent in rainy season (Table 5). The period had highly significant ($P \leq 0.01$) effect on replacement rates on total pregnancies basis (Table 4). The replacement rates on female calf basis were observed to be varying from 14.94 percent in 2nd Period to 30.48 percent in the 6th Period (Table 5). Significantly lower replacement rates during record period second may be because of very high abnormal births, death and culling rate during this period. The parity had non-significant effect on replacement rates on total pregnancies basis (Table 4). The replacement rates on female calf basis were observed to be varying from a lowest of 9.88 percent in sixth Parity to a highest value of 40.78 percent in third Parity (Table 5). No definite trend was observed for replacement rates among different dam's parities.

From the foregoing discussion on replacement rates computed on total female calves born and total pregnancies, it could be concluded that about 4 pregnancies are required to produce one heifer that becomes the replacement of the old and low productive cow against a norm of 2-3 pregnancies. Furthermore, in a progeny testing program, it can be recommended that about 38 pregnancies are required from each sire out of which about 16 should be turned into female births, so that about 10-12 daughters per sire may be available for performance recording.

The average incidences of pre-natal calf losses due to abnormal births in crossbred cattle were observed to be 9.12 percent among 2204 total births (Table 5). These differences in prenatal calf losses could be attributed to genetic and managemental or environmental reasons. The average mortality rates among the crossbred female calves born from birth to AFC were found to be 15.70 percent (Table 5). The overall female culling rate up to AFC, computed from total female calves born were estimated to be 30.15 percent (Table 5). The overall replacement rate on the basis of total female calves born were estimated to be 54.18 percent (the proportion of the female calves that reached to the AFC) and the rest 45.82 percent of female calves were lost due to their death and culling from the herd (Table 5). These values indicated that about 1/2 of the total females born reached to AFC and became the replacement to older cows in the herd. The overall replacement rates computed on the basis of total pregnancies in this crossbred herd under study were found to be 25.27 percent (Table 5). This observation indicated that about 4 pregnancies are required to produce one replacement heifer.

It may be concluded that replacement rates and its component traits are affected by periods, seasons, and parity. As expected, the heifer borne to younger dams have higher replacement rates.

Figures in parenthesis are percentage values

The effect of sire had a highly significant effect on AFC in the present study. Similarly, significant effects of sire were reported by Nehra *et al.* [9] in Karan Fries cattle. On the other hand, non-significant effects were observed by Dubey and Singh [10] in crossbred cattle. The period of birth had a non-significant effect on AFC in the present study. Similar results were also reported on this trait by Nehra *et al.* [9] in Karan Fries cattle. However, a significant effect of the period of birth on AFC was reported on this trait by Mukherjee [11] in Frieswal cattle. The season of calving had a significant ($P \leq 0.05$) effect on the FLMY-305 in the present study. Similar results were also reported by Dash *et al.* [12] in Karan Fries cattle. However, the non-significant effects were reported on this trait by Nehra *et al.* [9] in Karan Fries. The period of calving had a non- significant effect on the FLMY-305. Similar results were reported on the period of calving by Nehra *et al.* [9] in crossbred cattle. A significant effect was also reported on the period of calving by Dash *et al.* [12] in Karan Fries cattle. A significant effect was reported on AFC by Mukherjee [20] in Frieswal and Nehra *et al.* [22] in Karan Fries

Table 4. Analysis of variance (ANOVA) for showing the effect of non-genetic factors on replacement rate and its component of crossbred cattle

Source of Variation	DF	MSS				
		Abnormal birth	Female mortality	Female culling	Replacement rate	
					FC	TC(TP)
Period	5	0.6331*	0.4913**	0.7910**	2.3891**	1.6367**
Season	2	0.4133*	0.4132	0.1043	0.7832*	0.8754*
Parity	5	0.3139*	0.3011*	0.1324	0.5979*	0.5706
Error	2191	0.1331 (2191)	0.2976 (1028)	0.1013 (1028)	0.1653 (1028)	0.1950 (2191)

** $P \leq 0.01$; * $P \leq 0.05$

Figures in Parenthesis are the error degree of freedom, FC=Female Calf Basis, TP=Total Calf Basis (total Pregnancies)

Table 5: Per cent contribution of different components of replacement rate in relation to non-genetic factors

Effect	Total births	Abnormal birth	Normal births			Female calf			Replacement Rate (%)	
			Total	Male	Female	Died	Culled	Retained	FC	TC (TP)
Overall	2204	201 (9.12)	2003 (90.88)	975 (48.68)	1028 (51.32)	161 (15.70)	310 (30.15)	557	54.18	25.27
Season										
Winter	427	39 (9.13)	388 (90.87)	163 (42.01)	225 (57.99)	33 (14.66)	74 (32.89)	118	52.44	27.63
Summer	791	80 (10.11)	711 (89.89)	370 (52.32)	341 (47.96)	56 (16.42)	128 (37.53)	157	46.04	19.84
Rainy	986	82 (8.32)	904 (91.68)	442 (48.89)	462 (51.10)	72 (15.58)	108 (23.37)	282	61.03	28.60
Period										
1981-86	26	2 (7.69)	24 (92.31)	14 (58.33)	10 (41.67)	0 (0.00)	4 (40.00)	6	60.00	23.08
1987-92	87	9 (10.34)	78 (89.66)	41 (52.56)	37 (47.44)	8 (21.62)	16 (43.24)	13	35.14	14.94
1993-98	351	28 (7.98)	323 (92.02)	165 (51.08)	158 (48.92)	24 (15.18)	27 (17.08)	107	67.72	30.48
1999-04	479	46 (9.60)	433 (90.40)	186 (42.96)	247 (57.04)	36 (14.57)	98 (39.67)	113	45.75	23.59
2005-10	769	83 (10.79)	686 (89.21)	356 (51.89)	330 (48.10)	51 (15.45)	111 (33.63)	168	50.90	21.85
2011-16	492	33 (6.71)	459 (93.29)	213 (46.41)	246 (53.59)	42 (17.03)	54 (21.95)	150	60.98	30.48
Parity										
1	412	22 (5.34)	390 (94.66)	176 (45.13)	214 (54.87)	13 (6.07)	33 (15.42)	168	78.50	40.78
2	413	28 (6.78)	385 (93.22)	204 (52.99)	181 (47.01)	26 (14.36)	42 (23.20)	113	62.43	27.36
3	427	43 (10.07)	384 (89.93)	150 (39.06)	234 (60.94)	40 (17.09)	34 (14.53)	160	68.38	37.47
4	354	49 (13.84)	305 (86.16)	168 (55.08)	137 (44.92)	30 (21.89)	67 (48.90)	40	29.19	11.30
5	254	27 (10.63)	227 (89.37)	127 (55.95)	100 (44.05)	12 (12.00)	46 (46.00)	42	42.00	16.54
>6	344	32 (9.30)	312 (90.70)	150 (48.08)	162 (51.92)	40 (24.69)	88 (54.32)	34	20.99	9.88

FC=Female Calf Basis, TP=Total Calf Basis (Total Pregnancies)

cattle. The effects of sire on FLMY were found highly significant ($P \leq 0.01$) in the present study. Similarly, significant effects of sire were also reported on this trait by Mukherjee [11] in Frieswal cattle, Nehra *et al.* [9] in Karan Fries cattle. The period of calving had a non-significant effect on the FLMY. Similar results were reported on this trait by Saha *et al.* [13] in Karan Fries. The season of calving had a non-significant effect on FLMY. Similar results were reported by Saha *et al.* [13] in Karan Fries. However, significant effects were reported on this trait by Dash *et al.* [12] in Karan Fries cattle. The AFC had a highly significant ($P \leq 0.01$) effect on AFC. The least-squares means for FLMY varied from 2224.02 ± 125.46 for the 4th group (AFC ≥ 1500 days) to 2631.04 ± 110.39 days in the 3rd group (AFC = 1301-1500 days). Indicating that as for as FLMY is concerned the optimum AFC ranges in 1301-1500 days but at the same time, it will reduce the herd life and lifetime milk yield. Similar results were too described by Saha *et al.* [13] in Karan Fries. The period of calving had a significant ($P \leq 0.05$) effect on the FLL. The least-squares mean for the FLL varied from 308.57 ± 15.85 for Period 2 to 433.97 ± 40.79 days for Period 1. Suggesting that management in different periods influenced high lactation length vigorously. Similar results were reported in this trait by Nehra *et al.* [9] and Dash *et al.* [12] in Karan Fries cattle. However, non-significant effects were reported by Mukherjee [11] in Frieswal cattle. The effects of the season of calving on FLL were found non-significant as can be seen from Table 2. Similar results were reported on this trait by Nehra *et al.* [9] in Karan Fries. However, significant effects were reported on this trait by Dash *et al.* [12] in Karan Fries cattle. Similarly, a significant effect was reported on AFC by Saha *et al.* [13] in Karan Swiss cattle. The effect of sire had a highly significant ($P \leq 0.01$) effect on the FSP. Similarly, significant effects of sire were reported by Bhatia and Pandey [14] in crossbred cattle. However, the non-significant effects were reported by Mukherjee [11] in Frieswal cattle. The effect of the period of calving on the FSP was found to be highly significant. The least-squares means for the FSP varied from 192.70 ± 13.87 for Period-6 to 265.79 ± 8.56 days for Period-3. Similar results were reported in this trait by Divya [15] in Karan Fries cattle. However, the non-significant effects of the period on service period were reported on this trait by Bhatia and Pandey [14] in HF cross and Saha *et al.* [13] in Karan Fries cattle. The effects of season of calving on the FSP were found non-significant. Similar results were also reported in this trait by Divya [15] in Karan Fries cattle. However, significant effects were reported on this trait by Saha *et al.* [13] in crossbred cattle. The effect of sire had a non-significant effect on the FDP in the present study. Similarly, non-significant effects of sire were reported by Mukherjee [11] in Frieswal. However, significant effects were reported by Saha *et al.* [13] in Karan Fries cattle. The season of calving had a non-significant effect on the FDP as can be seen from Table 1. Similar results were also reported in this trait by Singh and Gurnani [16] in Karan Fries cattle. The AFC group had a non-significant effect on the FDP. Similar results were reported in this trait by Saha *et al.* [13] in Karan Fries cattle. However, the significant effects were reported by Mukherjee [11] in Frieswal. The effects of the period of calving on the FCI were found non-significant. Similar results were reported in this trait by Akhtar *et al.* [17] in HF crosses. However, the significant effects of the period on FCI were reported by Nehra *et al.* [22] in Karan Fries cattle. The season of calving had a non-significant effect on the FCI. Similar results were reported in this trait by Nehra *et al.* [9] in Karan Fries cattle. However, significant effects were reported on this trait by Mukherjee [11] in Frieswal cattle, and Hammoud *et al.* [18] in Holstein Friesian cross.

The sire effects are significant for all the traits under study except FDP and FCI indicating the importance of genetic factor (sire) in influencing dairy character. Other non-genetic factors seem to have less influence on the traits under study.

The overall least-squares means for AFC was found as 1277.75 ± 101.56 days. The result of the present finding is in close agreement with the findings of Dubey and Singh [10] in crossbreds. However, lower values of AFC have been observed by Nehra *et al.* [9] in Karan Fries cattle. The heritability estimates of AFC were found to be 0.31 ± 0.14 (Table 3). Similar findings were reported by Mukherjee [11] in crossbred cattle. Higher estimates of heritability of this trait were reported by Nehra [19] in crossbred cattle, while lower estimates were reported by PDC AR [20] in crossbred cattle. The moderate value of heritability for this trait suggested that improvement could be possible in this trait by genetic selection along with better management practices. The overall least-squares mean for the FLMY-305 was observed as 2673.48 ± 81.29 kg. The results of the present study were similar to those reported by Rao *et al.* [21] in crossbreds. The present value was lower to Karan Fries [22], Vrindavani [23] and Chawla *et al.* [24] crossbred cows under farm conditions and higher to HF×Deoni crossbred [25] cows, Dash *et al.* [12] and Nehra *et al.* [9] Karan Fries cattle. The heritability of the FLMY-305 was observed as 0.37 ± 0.12. Similar estimates were reported by Nehra [19] and Dash *et al.* [12] in Karan Fries cattle. However, a comparatively lower value was reported by Rashia [26] in crossbred cattle. The higher estimates of heritability for this trait indicated that this production trait is more influenced by additive genetic variability and, therefore, there is scope for improvement by selection with proper management practices. The overall least-squares mean for the FLMY was found to be 2746.23 ± 85.51 kg. The results of the present study were similar to those reported by Bhattacharya *et al.*, [27] in Karan Fries. However, the higher values of first lactation milk yield have been observed by Mukherjee [11] in Frieswal. Hadge *et al.* [28] reported a lower estimate for FLMY for Jersey crossbred and Kharkar *et al.* [29] also reported a lower estimate for first lactation milk yield in Jersey x Red Kandhari than the present study. The heritability of the first lactation milk yield was estimated as 0.27 ± 0.07. However, lower values were estimated by Mukherjee [11] in crossbred cattle. The overall least-squares mean for the FLL was found to be 346.02 ± 7.44 days. The present value was in agreement with those reported in Frieswal cow (342.97 ± 12.14 days) by Minj *et al.* [30]. The present value was lower for Karan Fries [22] and Vrindavani [23] crossbred cows under farm conditions and higher for HF×Deoni crossbred [25] cows. However, the higher values of FLL have been observed by Nehra [19] in Karan Fries cattle while Kharkar *et al.* [29] reported lower lactation length in Jersey x Red Kandhari cattle than the present study. The FLL being the period of actual milk production, farmers try to increase it as much as possible. Simultaneously, nowadays farmers are also aware of the importance of an optimum dry period. Hence, there is always a compromise between these two traits. It has been observed that some farmers deliberately go on milking their pregnant cows for which they are not interested to keep their herd in the next lactation [30]. The heritability estimate of first lactation length was found to be 0.17 ± 0.08. Almost similar estimates were reported by Nehra [19] in crossbred cattle. However, the lower values than the present study were reported by Dash *et al.* [12], in crossbred cattle. Since this trait is lowly heritable it can be improved by employing family selection and better husbandry practices. The overall least-squares mean of the FSP was found as 165.91 ± 5.39 days (Table 1). The estimate was quite similar to those reported by Mukherjee [11] in Frieswal. However, the lower values of the FSP have been observed by Divya [15] in Karan Fries cattle. As the trait is governed by non-genetic factors, hence managemental practices may be improved for lowering the FSP. The overall least-squares mean of the FDP was observed as 139.15 ± 7.53 days. The estimates were similar to those reported by Mukherjee [11] in Frieswal. However, the lower values of the FDP have been observed by Kharkar *et al.* [29] in Jersey x Red Kandhari cattle. The heritability estimate of the FSP and FDP was found to be 0.24 ± 0.13 and 0.17 ± 0.11. The estimates of heritability similar to the present study were observed by Saha *et al.* [13] in crossbred cattle. However, the lower estimates of heritability than the present study were reported by Mukherjee [11] in crossbred cattle and the higher estimates of heritability for this trait than the present study were observed by Gaur [32] in crossbred cattle. The moderate value of heritability for this trait indicates little influence of genetic factors over this trait. Hence, this trait can be improved only through managemental interventions. The overall least-squares mean of the FCI was found as 489.01 ± 9.79 days. The lower values of the FCI have been observed by Nehra *et al.* [9] in Karan Fries cattle. Higher values than the present study were observed by Yadav *et al.* [33] in crossbred cattle. The heritability estimate of the FCI was found to be 0.21 ± 0.09. The estimates of heritability similar to the present study were reported by Nehra [19] in crossbred cattle. Higher values were reported by Saha *et al.* [13] in crossbred cattle, while lower values than the present study were reported by Mukherjee [11] in crossbred cattle.

The crossbred herd under the study had higher AFC, FSP, FDP, and FCI which can be reduced to optimum levels by selection and improved husbandry practices, as there exists huge variation in these traits within the herd. The heritability estimates for most of the traits are moderate indicating that there exists scope for improvement in these traits through genetic selection.

The period had a significant ($P \leq 0.05$) effect on pre-natal calf losses in the present study. The pre-natal calf losses due to abnormal births in crossbred cattle were observed to be varying from 6.71 percent in period VI to 10.79 percent in period V, showing no pattern during different periods. Similarly, significant effects of the period were reported by Singh *et al.* [34] in Holstein x Sahiwal. Furthermore, the sudden increase in the incidence of pre-natal calf losses due to abnormal birth during the II period could be due to some unpredicted managemental/environmental or health problems in the herd. The seasons had a significant ($P \leq 0.05$) effect on pre-natal calf losses in the present study. The pre-natal calf losses due to abnormal births in crossbred cattle were observed to be varying from 8.32 percent in the rainy season to 10.11 percent in the summer season. Similarly, significant effects of seasons were reported by Singh *et al.* [34]. However, non-significant season effects on pre-natal calf losses due to abnormal births were observed by

Singh *et al.* [34] in crossbred cattle. The parity had a significant (P ≤ 0.05) effect on pre-natal calf losses in the present study. The pre-natal calf losses due to abnormal births in crossbred cattle were observed to be varying from 5.34 percent (Parity 1) to 13.84 percent (Parity 4). There is no definite trend in pre-natal calf losses due to abnormal births among parity of calving on this trait. Similarly, significant effects of parity were reported by Mukherjee and Tomar [35] in Karan Swiss cattle. However, non-significant parity effects on pre-natal calf losses due to abnormal births were observed by Singh [31] in crossbred cattle. There is no definite trend in pre-natal calf losses due to abnormal births among parity of calving on this trait. The period had a highly significant (P ≤ 0.01) effect on mortality rates in the present study (Table 4). The mortality rates in female calves in crossbred cattle were observed to be varying from 14.57 percent during Period IV to 21.62 percent during Period II. These significant period differences in mortality rates of female calves could be attributed to management and environmental reason. Similarly, significant effects of the period were reported by Singh [31] in Karan Fries cattle. Seasons had a non-significant effect on mortality rates in the present study. Similarly, non-significant effects of seasons were reported by Singh [31] for crossbred cattle herds. However, the significant season effects on mortality rates have been observed by Singh *et al.* [34] in crossbred calves. Parity had a significant (P ≤ 0.05) effect on mortality rates in the present study (Table 4). The mortality rates in female calves in crossbred cattle were observed to be varying from 6.07 percent (Parity 1) to 24.69 percent (Parity 6). Similarly, significant effects of parity were reported by Singh *et al.* [34] for crossbred female calves. However, the non-significant parity effects on mortality rates have been observed by Singh [31] in Karan Fries cattle. Period of birth had a highly significant (P ≤ 0.01) effect on culling rates in the present study (Table 5). The culling rates in female calves in crossbred cattle were observed to be varying from 21.95 percent in Period VI and 43.24 percent in Period II. The culling among the heifers is generally practiced as per the need of the herd and the type of stock available for replacement. Therefore, generally culling is not practiced uniformly over different periods, which may result in a significant variation in the culling of heifers. Similarly, significant effects of the period were reported by Singh [31] for Karan Fries's female calves. Seasons had a non-significant effect on culling rates in the present study. Similarly, non-significant effects of seasons were reported by Singh [31] for Karan Fries calves. Parity had a non-significant effect on the culling rate in the present study. Similarly, non-significant effects of parity were reported by Singh [31] for Karan Fries cattle. Period of birth had a highly significant (P ≤ 0.01) effect on replacement rates on the female calf basis in the present study. The replacement rates on the female calf basis were observed to be varying from 35.14 percent in II Period to 60.98 percent in Period VI. The lowest replacement rate during the second period could be due to the observed higher mortality and culling rates among female calves. Similarly, significant effects of the period were reported by Singh [31] in Karan Fries. The season had a significant (P ≤ 0.05) effect on replacement rates on the female calf basis in the present study. The replacement rates on the female calf basis were observed to be varying from 46.04 percent in the summer season to 61.03 percent in the rainy season. On the other hand, non-significant effects were observed by Singh [31] in Karan Fries cattle. Parity had a significant (P ≤ 0.05) effect on replacement rates on the female calf basis in the present study. The replacement rate on the female calf basis was observed to be varying from 20.99 percent in sixth Parity to 78.50 percent in first Parity. Though there was no definite trend between the dam's parity and replacement rate. On the other hand, non-significant effects were observed by Singh [31] in Karan Fries cattle. Period of birth had a highly significant (P ≤ 0.01) effect on replacement rates on total pregnancies basis in the present study. The replacement rates on the female calf basis were observed to be varying from 14.94 percent in Period II to 30.48 percent in Period VI. Significantly lower replacement rates during the recording period II may be because of very high abnormal births, death, and culling rate during this period. Similarly, significant effects of the period were reported by Singh [31] for Karan Fries cattle. Seasons had a significant (P ≤ 0.05) effect on replacement rates on total pregnancies basis in the present study. The replacement rates on the female calf basis were observed to be varying from 19.84 percent in the summer season to 28.60 percent in the rainy season. On the other hand, non-significant effects were observed by Singh [31] in crossbred cattle. Parity had a non-significant effect on replacement rates on total pregnancies basis in the present study. The replacement rates on a female calf basis were observed to be varying from the lowest of 9.88 percent in the sixth Parity to the highest value of 40.78 percent in the third Parity. No definite trend was observed for replacement rates among different dam's parities. Similarly, significant effects of the period were reported by Singh [31] in Karan Fries cattle.

It may therefore be concluded that about 4 pregnancies are required to produce one heifer that becomes a replacement of the old and low-productive cow against a norm of 2-3 pregnancies. Furthermore, in a progeny testing program, it can be recommended that about 38 pregnancies are required from each sire out of which about 16 should be turned into female births, so that about 10-12 daughters per sire may be available for performance recording.

The average incidences of pre-natal calf losses due to abnormal births in crossbred cattle were observed to be 9.12 percent among 2,204 total births. A higher incidence of pre-natal calf losses than this present estimate was observed by Singh *et al.* [34] in HF × Sahiwal cattle. However, lower pre-natal calf losses due to abnormal births were observed by Singh [31] in Karan Fries. These differences in prenatal calf losses could be attributed to genetic and managemental or environmental reasons. The average mortality rate among the crossbred female calves born from birth to age at first calving was found to be 15.70 percent. The overall female culling rate up to the age at first calving, computed from total female calves born was estimated to be 30.15 percent. The higher culling rates among female calves than the present study were reported by Singh [31] in Karan Fries. The overall replacement rate based on total female calves born was estimated to be 54.18 percent (the proportion of the female calves that reached the AFC) and the rest 45.82 percent of female calves were lost due to their death and culling from the herd (Table 4). These values indicated that about 1/2 of the total females born reached AFC and became the replacement to older cows in the herd. The lower replacement rates among female calves than the present study were reported by Singh [31] in Karan Fries cattle. The overall replacement rates computed based on total pregnancies in this crossbred herd under study were found to be 25.27 percent. This observation indicated that about 4 pregnancies are required to produce one replacement heifer.

It may be concluded that replacement rates and their component traits are affected by periods, seasons and parity. As expected, the heifers borne to younger dams have higher replacement rates.

Conclusion

Based on ours finding the ANOVA revealed that there were no significant differences for almost all the first lactation traits understudy for different seasons and periods which were obvious because standard practices were adopted at the farm and adjustments to any situations were made as and when required. A highly significant effect of sire on almost all the first lactation traits indicated that superior sires had been used from time to time for the overall improvement of the herd. The study revealed a highly significant effect of the AFC group on milk yield in crossbred cattle. Early calvers produced comparatively lower milk than the optimum calvers. The crossbred herd under the study seems to have moderate productivity but higher AFC, FSP, FDP, and FCI which can be reduced to optimum levels by selection and improved husbandry practices, as there exists huge variation in these traits within the herd. The heritability estimates for first lactation traits were observed low to medium which revealed that genetic variability in these traits was existing and these traits could be improved through genetic selection along with better feeding and management practices. Four pregnancies were required to produce one replacement heifer. Heifers born to younger dams have a higher replacement rate.

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