STUDIES ON GENETIC TRENDS OF PRODUCTION AND REPRODUCTION TRAITS IN SAHIWAL AND CROSSBRED CATTLE

Thesis

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Pantnagar
January, 2019

(Sanjay Dutt Gahtori)
Author

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON GENETIC TRENDS OF PRODUCTION AND REPRODUCTION TRAITS IN SAHIWAL AND CROSSBRED CATTLE"** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** with major in **Animal Genetics and Breeding** of the College of Post Graduate Studies, G.B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona fide* research carried out by **Mr. Sanjay Dutt Gahtori,** Id. No. **41447** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

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Chairman
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Mr. Sanjay Dutt Gahtori,** Id. No. **41447,** a candidate for the degree of **Master of Science in Agriculture** with major in **Animal Genetics and Breeding**, agree that the thesis entitled **"STUDIES ON GENETIC TRENDS OF PRODUCTION AND REPRODUCTION TRAITS IN SAHIWAL AND CROSSBRED CATTLE"** may be submitted in partial fulfilment of the requirements for the degree.

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ABBREVIATIONS

FL305DMY	=	First lactation 305 days milk yield
FLMY	=	First lactation milk yield
FLL	=	First lactation length
AFC	=	Age at first calving
FCI	=	First calving interval
FDP	=	First dry period
FSP	=	First service period
FLMY / FLL	=	First lactation milk yield per day of lactation length
FLMY / FCI	=	First lactation milk yield per day of calving interval
CV	=	Coefficient of variation
SD	=	Standard deviation
SE	=	Standard error
h^2	=	Heritability
LSM	=	Least squares mean
d.f.	=	Degree of freedom
F x K	=	Friesian x Kankrej
BS X T	=	Brown Swiss X Tharparkar
HF/BS/J X O	=	Friesian/ Brown Swiss /Jersey X Ongole
F/R x S	=	Friesian/Red Dane x Sahiwal
HF	=	Holstein Friesian
J x H	=	Jersey x Hariana
J x K	=	Jersey x Kankrej
J x S	=	Jersey x Sahiwal
KF	=	Karan Fries
KS	=	Karan Swiss
NS	=	Non significant
S	=	Significant

Introduction

Chapter 1 INTRODUCTION

India is predominantly an agricultural based economy and livestock is an essential component of it. Dairy sector plays a critical role in the country's agricultural economy. The share of gross value added by the livestock sector to the agriculture sector has increased from 21.8% in 2011-12 to 25.7% in 2015-16 **(BAHS, 2018)**. According to the **livestock census (2012)**, India had 190.90 million cattle, of this, 151.17 million are indigenous (78.9%) and 39.73 million are crossbreds (21.1%). Most of the indigenous cattle are non-descript which contribute 9.5% of total milk production in India **(BAHS, 2018)**. Out of indigenous cattle, there are 43 well-recognized breeds of cattle which are registered at present by **NBAGR, Karnal**. At present India is the highest milk producing country in the world. Milk production during 2015-16 and 2016-17 was 155.5 million tonnes and 165.4 million tonnes, respectively, showing an annual growth of 6.37% **(BAHS, 2018)**. Crossbred cattle contribute 25.4% to the total milk produced **(BAHS, 2018)**, which plays a vital role in the rural economy of the country.

Sahiwal cattle are mainly known for their hot climate and disease resistance, low maintenance cost and higher percentage of milk constituents. It is one of the best milch breed of indigenous cattle. The breeding tract of this breed is though in Montgomery district in Pakistan, some herds of this breed are also found along the Indo-Pak borders of Ferozepur and Amritsar district of Punjab and Sri Ganganagar district in Rajasthan. Sahiwal breed is also maintained in Haryana, UP and Chattisgarh as organised dairy farms. This breed has higher demand among the indigenous breeds. It is being widely used for the improvement of local stock through upgrading in some states of India. It has been used for the production of different strains all over the world such as Jamaica Hope, Australian Friesian Sahiwal. In India, Karan Swiss has been developed by crossing Sahiwal with Brown Swiss and Frieswal has been developed by crossing Sahiwal and Holstein Friesian.

Crossbreeding of the indigenous cows (*Bos indicus*) with exotic (*Bos taurus*) bulls was started to reinforce the genetic potential of milk production in the subsequent crossbred programmes. The basic theme was to conflux the milk yield potential of

exotic breeds and stress sustainability and disease resistance capabilities of indigenous breeds within the crossbred progenies, which would be desirable to maintain them under tropical climatic conditions.

It is well understood that crossbreeding can improve the overall production performance with moderate adaptability in the F_1 generation. However, if the crossbreeding is indiscriminate and uncontrolled, it may result in reduced productive advantage **(Hosein and Masoud, 2011)**. Hence, the genetic programme implemented needs to be evaluated periodically to determine the improvement as well as to plan the future breeding strategy for improving the productivity. The estimation of genetic and phenotypic trends for various performance traits over the years reflects the effectiveness of the breed improvement programme implemented. **Hudson and Kennedy (1985)** suggested that the estimation and interpretation of the genetic trend estimates allow monitoring of the efficiency of improvement strategies and assures that the selection pressure is directed towards the traits of economic importance. It will also help in redefining the breeding strategies if the trend is not as desired so as to improve the profitability and sustainability of the performance. The estimation of selection in the breeding programme can be done by estimating change per year in the performance of the traits under consideration. The observed change in the performance of a population for an economic trait per year, i.e. phenotypic trend consists of two components viz. genetic trend resulting from a change in mean breeding value due to selection and an environmental trend due to cumulative change in various non-genetic factors.

"Genetic trend is the change in performance per unit time due to the change in mean breeding value" **(Harville and Handerson, 1967)**. Many studies have analyzed the genetic trends by means of the regression of the breeding value estimated in time **(Lee *et al.*, 1985)** or the regression of the production in time for the estimation of the phenotypic tendencies **(Powell and Freeman, 1974)**. The appraisal of the trends is essential because they permit comparison of realized trends with an expected one in the experimental situation and assessment of progress in a particular trait. The magnitude of genetic trends must be known for comparison of sires. Several methods have been developed to measure the genetic trend in the animal population **(Smith, 1962; Powell and Freeman, 1974)**.

"Phenotypic trends are the changes in yearly means over the years, which include both the genetic and the environmental components. In general, favourable phenotypic and genetic trends can be achieved if the environment and breeding management are improved" **(Hintz *et al.*, 1978)**. So, there is a need to assess the phenotypic and genetic trends and observe whether the trends are desirable for each trait or not.

Breeding and selection process of a given dairy farm depends on the financial importance of animals on that farm and products that can be obtained from it. The first step in the genetic selection and breeding of producing animal is recording of the milk yield and when the results are correctly pooled with the pedigree information, the genetic value of milk production could be estimated for each animal **(Borghese, 2005)**. Lifetime production of a dairy animal is the sign of its effectiveness and it is influenced by important fertility parameters, such as the interval between calvings, lactation length and the probability of staying alive from one lactation to another **(Hossein-Zadeh, 2011)**. Age at first calving (AFC) includes the time interval an animal requires to reach puberty and produce offspring for the first time. The calving interval indicates the time interval between the first calving and subsequent calving. These indicators of reproductive success influence the financial perspective of milk production **(Grohn and Rajala-Schultz, 2000)**.

AFC recognized as the start of the lifetime production of a dairy cow and the effect on its overall production **(Ojango and Pollott, 2001)**. There was a genetic antagonism between milk yield and traits associated with fertility and reproductive efficiency in cattle **(Marti and Funk, 1994).**

The reproductive traits of cow have economic importance because cows that calve early and have regular calving intervals, produce more calves in less time, constantly increase the substitution rate of females and the efficiency of the farm **(Aby *et al.*, 2012)**. Therefore, productive and reproductive traits need to be analyzed for consideration as selection criteria according to the breeding goal.

The genetic parameters such as heritability and genetic correlations are useful in determining the selection policy for a single or multiple selection objectives. The influence of non-genetic factors on different economic traits is required to be evaluated

to adjust the data for significant non-genetic factors to estimate genetic parameters of the population. Genetic and phenotypic trends in production and reproduction traits are important because they allow for the evaluation of the efficacy of selection and management schemes. Therefore, the present study was proposed with the followings objectives in Sahiwal and crossbred cattle as:

a) To study the effect of genetic and non-genetic factors on production and reproduction traits.

b) To estimate genetic parameters for production and reproduction traits.

c) To estimate the genetic and phenotypic trends of production and reproduction traits.

Review of Literature

Literature was compiled on a variety of topics, such as performance levels, the effect of genetic and non-genetic factors, genetic and phenotypic parameters of the first lactation traits and estimates of the genetic and phenotypic trends of production and reproduction traits of different cattle. Therefore, the available literature on the objectives of this study has been reviewed in the following headings for each traits understudy:

- Means of first lactation traits.
- Genetic and non-genetic factors affecting the first lactation traits.
- Heritability estimates of first lactation traits.
- Genetic and phenotypic correlation among different first lactation traits.
- Genetic and phenotypic trends of production and reproduction traits.

2.1 Means, effect of genetic and non-genetic factors, heritability and genetic and phenotypic correlations for the first lactation traits

The literature existing on numerous first lactation traits namely, first lactation 305 days milk yield, first lactation milk yield, first lactation length, age at first calving, first calving interval, first dry period, first service period, first lactation milk yield per day of first lactation length, first lactation milk yield per day of first calving interval have been reviewed as under following sub-headings.

2.1.1 First Lactation 305 Days Milk Yield (FL305DMY)

The average, heritability and factors affecting the FL305DMY in Sahiwal and crossbred cattle as reported by several authors have been summarized in Table 2.1.1

2.1.1.1 General performance

The average of FL305DMY reported by various authors varied from 1,393 ± 12 kg **(Rehman *et al.,* 2008)** to 2083.75 ± 30.06 kg **(Parveen *et al.,* 2018)** in Sahiwal and 2470 ± 20 kg **(Saha, 2001)** to 3562 ± 27 kg **(Rashia, 2010)** in crossbred cattle.

Table 2.1.1 Means, heritability and factors affecting the first lactation 305 days milk yield (kg) in Sahiwal and crossbred cattle

Breed group	Location	Mean ± S.E.	Heritability (h^2 ± SE)	Effect of				References
				Sire	Season	Period	AFC	
1	2	3	4	5	6	7	8	9
HF X Sahiwal	HAU	2523 ± 42	-	-	S	S	-	**Dalal *et al.* (1991)**
HF X Sahiwal	MDF	2381 ± 45		-	NS	S	-	**Jadhav *et al*. (1991)**
KS	NDRI	2758 ± 116	0.79 ± 0.13	S	S	S	-	**Dutt and Joshi (1992)**
KS	NDRI	2615 ± 82	0.49 ± 0.17	S	NS	NS	NS	**Singh (1995)**
KF	NDRI	3173 ± 82.	-	S	NS	S	NS	**Singh (1995)**
KS	NDRI	3199 ± 44	0.21 ± 0.16	S	NS	S	NS	**Panja (1997)**
KF	NDRI	2919 ± 45	0.41 ± 0.13	-	S	S	-	**Sahana and Gurnani (2000)**
Crossbreds	Bangalore	2625 ± 37	-	NS	S	NS	NS	**Rao *et al.* (2000)**
KS	NDRI	2747 ± 113	-	NS	NS	S	-	**Mandal and Sachdeva (2001)**
KS	NDRI	2444 ± 22	-	-	S	S	-	**Saha (2001)**
KF	NDRI	2470 ±20	0.30 ± 0.02	-	S	S	-	**Saha (2001)**
Frieswal	MDF	2850 ± 77	-	-	S	S	S	**PDC AR (2003 -04)**
KF	NDRI	3173 ± 82	-	-	S	NS	-	**Singh and Gurnani (2004)**
Sahiwal	NDRI	1941± 59	0.57 ± 0.09	-	NS	S	-	**Raja (2004)**
Frieswal	MDF	2805 ± 18	0.20 ± 0.04	S	S	S	S	**Mukherjee (2005)**
KF	NDRI	3197 ± 43	0.45 ± 0.18	-	NS	S	-	**Singh *et al.* (2006)**
Sahiwal	Pakistan	1,393 ± 12	0.11 ± 0.029	-	S	S	S	**Rehman *et al.,* (2008)**
KF	NDRI	3562 ± 27	0.20 ± 0.06	-	NS	_	-	**Rashia (2010)**
KF	NDRI	3243.59 ±47.33	0.48 ± 0.14	S	NS	NS	S	**Nehra (2012)**
Sahiwal	Pakistan	1530.5±12.36	-	-	S	S	-	**Reham and khan (2012)**
Mpwapwa cattle	Tanzania	1,686.0 ± 578.6	-	-	-	-	-	**Chawla *et al.*(2017)**
KF	NDRI	3634.78 ± 30.91	0.39 ± 0.09	S	S	S	-	**Dash *et al.* (2016)**
Sahiwal	NDRI	2083.75 ± 30.06	0.18 ± 0.11	S	S	S	S	**Parveen *et al.,* (2018)**

2.1.1.2 Genetic and non-genetic factors affecting the first lactation 305 days milk yield

Parveen *et al.* (2018) observed significant effect of sire on FL305DMY in Sahiwal, **Singh and Gurnani (2004)** in Karan Fries, **Mukherjee (2005)** in Frieswal and **Dash *et al.* (2016)** in KF cattle, but **Rao *et al.* (2000)** and **Mandal and Sachdeva (2001)** reported insignificant effect of sire on FL305DMY.

The insignificant effect of the period of calving on FL305DMY was observed by **Rao *et al.* (2000)** in crossbred, **Singh and Gurnani (2004)** and **Nehra *et al.* (2013)** in KF cattle, while significant effect was found by **Singh *et al.* (2006)**, **Dash *et al.* (2016)** in KF and **Parveen *et al.* (2018)** in Sahiwal cattle.

The insignificant effect of season of calving on FL305DMY was observed by **Raja (2004)** in Sahiwal, **Singh *et al.* (2006)**, **Rashia (2010)** and **Nehara *et al.* (2012)** in KF, while significant effect was found by **Mukherjee (2005)** in frieswal, **Dash *et al.* (2016)** in KF and **Parveen *et al.* (2018)** in Sahiwal cattle.

2.1.1.3 Heritability

The heritability studied for FL305DMY reported by different authors varied from 0.11 ± 0.11 **(Rehman *et al.,* 2008)** to 0.57 ± 0.09 **(Raja, 2004)** in Sahiwal and 0.20 ± 0.04 **(Mukherjee, 2005)** to 0.79 ± 0.13 **(Dutt and Joshi, 1992)** in crossbred cattle, as given in Table 2.1.1.

2.1.1.4 Genetic and phenotypic correlation

Mukherjee (2005) reported the genetic correlation estimates as 0.13 ± 0.17, 0.18 ± 0.23, 0.26 ± 0.24 and 0.17 ± 0.24 for FL305DMY with.FLL, FSP, FDP and FIC, respectively, in Frieswal cattle.

Dash (2014) estimated the genetic correlation of FL305DMY with FLMY, FLL, FSP and FCI as 0.91 ± 0.07, 0.38 ± 0.25, 0.09 ± 0.33 and 0.17 ± 0.36, respectively in KF cattle.

2.1.2 First Lactation Milk Yield (FLMY)

The mean, heritability and factors influencing the FLMY in Sahiwal and crossbred cattle as reports by different authors have been summarized in Table 2.1.2.

Table 2.1.2 Means, heritability and factors affecting the first lactation milk yield (kg) in Sahiwal and crossbred cattle

Breed	Location	Mean ± S.E.	Heritability (h^2 ± SE)	Effect of				References
				Sire	Season	Period	AFC	
1	2	3	4	5	6	7	8	9
Sahiwal	Nagpur	1259.00 ± 44.00	0.56 ± 0.44	-	-	-	-	**Deb *et al.*(1981)**
Sahiwal	NDRI	2264.60	0.52 ± 0.16	-	NS	S	-	**Reddy (1983)**
HF X Sahiwal	NDRI	1987 ± 14	0.45 ± 0.16	-	NS	S	-	**Pyne *et al*. (1988)**
HF X Sahiwal	MDF	2466 ± 99	0.24 ± 0.02	S	NS	S	-	**Tajane and Rai (1989)**
HF X Sahiwal	MDF	2495 ± 50	0.38 ± 0.07	-	NS	S	-	**Jadhav *et al*. (1991)**
Sahiwal	GLF, Ganjaria	1510.10 ± 19.53	0.24 ± 0.09	-	S	S	-	**Singh (1992)**
Frieswal	MDF	2730 ± 61	-	-	-	-		**Arora *et al.* (1993)**
HF X Sahiwal	MDF	3255 ± 27	0.16 ± 0.10	-	NS	S	-	**Raheja *et al*. (1994)**
HF X Hariana	MDF	3255 ± 27	0.22 ± 0.12	S	S	S	S	**Raheja *et al*. (1994)**
KS	NDRI	2952 ± 120	0.42 ± 19	-	NS	NS	NS	**Singh (1995)**
KF	NDRI	3676 ± 135	0.35 ± 0.12	S	NS	NS	NS	**Singh (1995)**
KF	NDRI	3599 ± 54	0.26 ± 0.05	S	NS	NS	NS	**Panja (1997)**
KF	NDRI	3617 ± 49	-	S	S	S	-	**Sivakumar (1998)**
KF	NDRI	3908 ± 124	-	-	S	NS	-	**Sinha (1999)**
KF	NDRI	3383 ± 69	0.32 ± 0.08	-	S	NS	S	**Sahana and Gurnani (2000)**
HF X H	IVRI	1950	-	NS	S	S	-	**Dutt and Kumar (2000)**
HF X J X H	IVRI	2091	-	NS	S	S	-	**Dutt and Kumar (2000)**
KS	NDRI	2791 ± 137	0.27 ± 0.04	NS	S	S	NS	**Saha (2001)**
KF	NDRI	2823 ± 122	0.27 ± 0.04	S	S	NS	S	**Saha (2001)**
HFXT (F1)	CCBF, Lakhimpur (UP)	2753 ± 67	-	NS	NS	NS	-	**Bhattacharya *et al* (2002)**
HFXT (F2)	CCBF, Lakhimpur	1748 ± 170	-	NS	NS	S	-	**Bhattacharya *et al* .(2002)**
5/8HF X 3/8 SW	GBPUAT,MDF	2995 ± 59	-	S	S	S	-	**Akhtar *et al*.(2003)**
5/8HF X 3/8 SW	GBPUAT,MDF	2529.95 ± 58	-	S	S	S	-	**Akhtar *et al*.(2003)**
Crossbred	Mathura	2269.0 ± 162	-	-	-	-	-	**Yadav *et al.*(2004)**
Sahiwal	NDRI	1941.59 ± 59	0.58 ± 0.2	-	NS	S	-	**Raja (2004)**
Sahiwal	GLF, Ganjaria	1687.81 ± 26.81	0.53 ± 0.12		NS	S		**Banik (2004)**
Frieswal	MDF	3042.11± 21	0.16 ± 0.04	S	S	S	NS	**Mukherjee (2005)**
Sahiwal	GBPUA&T, Pantnagar	2371.64 ± 94.73	0.95 ± 0.24	-	NS	S	-	**Singh et al (2005)**
Sahiwal	GBPUA&T, Pantnagar	1424.20 ± 26.70		-	-	-	-	**Abbas *et al.* (2010)**
Sahiwal	Pakistan	1552.1 ± 12.15	-	-	S	S	S	**Reham and khan (2012)**
Sahiwal	GBPUA&T, Pantnagar	1941.16 ± 27.66	-	S	NS	S	-	**Singh and Singh (2016)**
Sahiwal	NDRI	2070.41±79.20	0.19 ± 0.10	S	S	S	S	**Parveen *et al.*, (2018)**

2.1.2.1 General performance

The average FLMY in Sahiwal cattle varied from 1259.00 ± 44.00 kg **(Deb *et al.*, 1981)** to 2371.64 ± 94.73 kg **(Singh *et al.,* 2005)** and the same in crossbred cattle varied from 1987 ± 14 kg in HF x Hariana crossbred cattle (**Pyne *et al*., 1988)** to 3908 ± 124 kg in Karan Fries cattle **(Sinha,1999)**.

2.1.2.2 Genetic and non-genetic factors affecting FLMY

significant effect of sire on FLMY was observed by **Mukherjee (2005)** in Frieswal cattle, **Nehra *et al.* (2013)** in KF, **Sing and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle. However, the insignificant effect of sire was observed by **Dutt and Kumar (2000)** and **Bhattacharya *et al* (2002)**.

The insignificant effect of period on FLMY was found by **Sahana and Gurnani (2000)** and **Saha (2001)** in KF, while the significant effect was reported by **Sing and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle.

Bhattacharya *et al.* (2002) observed insignificant effect of season on FLMY in HF crosses, **Saha (2001)** in KF, while the significant effect was found by **Dash *et al.* (2016)** in KF and **Parveen *et al.* (2018)** in Sahiwal cattle. Significant effect of age at first calving was reported by **Saha (2001)** and **Sahana and Gurnani (2000)** in KF while the non-significant effect was found by **Panja (1997)** in KF and **Mukherjee (2005)** in Frieswal cattle.

2.1.2.3 Heritability

The heritability studied of first lactation milk yield of Sahiwal and crossbred cattle as observed by different authors varied from 0.19 ± 0.10 **(Parveen *et al.,* 2018)** to 0.95 ± 0.24 **(Singh *et al*., 2005)** and 0.16 ± 0.04 **(Mukherjee 2005)** to 0.45 ± 0.16 **(Pyne *et al*., 1988),** as given in Table 2.1.2.

2.1.2.4 Genetic and phenotypic correlations

The genetic correlations of first lactation milk yield with first lactation length varied from -0.770 ± 0093 **(Singh, 1992)** to 0.48 ± 0.04 **(Rao, 1985).**

Rao (1985) reported low and negative (-0.19 ± 0.26) phenotypic correlation between FLMY and FLL. Significant genetic and phenotypic correlations of magnitude of 0.35 ± 0.18 and 0.43 ± 0.09, respectively between FLMY and FLL were estimated by **Sharma and Singh (1981).**

Ahmad *et al.* (2001) observed the higher (0.63) genetic correlation between AFC and FLMY, whereas **Tomar *et al.* (1974)** observed near to zero and insignificant (-0.03) genetic correlation between both the traits**.**

Singh *et al.* (1999) reported genetic correlation of -0.525 ± 0.350 and phenotypic correlation of -0.189 ± 0.046 between first lactation milk yield and FDP.

Ahmad *et al.* (2001) reported high and negative (-0.96) genetic correlation of FLMY with FSP whereas **Singh *et al.* (1999)** reported positive (0.378 ± 0.320) genetic correlation between these traits.

The genetic correlation of FLMY with FL305DMY, FLL, FSP, FDP and FCI were found to be positive as reported by **Mukherjee (2005)** and the estimates were reported as 0.97 ± 0.01, 0.35 ± 0.16, 0.30 ± 0.23, 0.18 ± 0.25 and 0.28 ± 0.24, respectively in Frieswal cattle**. Kumar *et al.* (2008)** also found a positive genetic correlation of 0.59 ± 0.40 between FLMY and FLL in Frieswal cattle.

2.1.3. First Lactation Length (FLL)

The mean, heritability and factors affecting the first lactation length (FLL) in Sahiwal and crossbred cattle as reports by different workers have been summarized in Table 2.1.3.

2.1.3.1 General performance

FLL varied from 245.03 ± 12.18 days **(Mohnaty 2001)** to 349.70 days **(Reddy, 1983)** and 247.87 ± 18.58 days (**Bhattacharya *et al.*, 2002)** to 359.92 ± 4.33 days **(Nehra, 2012)** in Sahiwal and crossbred cattle, respectively.

2.1.3.2 Genetic and non-genetic factors affecting FLL

Significant effect of sire on FLL was reported by **Nehra (2012)**, **Dash *et al.* (2016)** in Karan fries, while the non-significant effect was found by **Saha (2001)** in KF and **Mukherjee (2005)** in Frieswal.

Significant effect of period of calving on FLL was found by **Saha (2001)** in Karan Swiss, **Nehra (2012)** and **Dash *et al.* (2016)** in Karan fries and **Parveen *et al.* (2018)** in Sahiwal cattle. however, the insignificant effect was found by **Panja (1997)** and **Saha (2001)** in KF and **Mukherjee (2005)** in Frieswal cattle.

Table 2.1.3 Means, heritability and factors affecting the first lactation length (days) in Sahiwal and crossbred cattle

Breed	Location	Mean ± S.E.	Heritability (h^2 ± SE)	Effect of				References
				Sire	Season	Period	AFC	
1	2	3	4	5	6	7	8	9
Sahiwal	NDRI	349.70	0.14 ± 0.09	-	S	S	-	**Reddy (1983)**
HF X Sahiwal	JNKVV	340 ± 16	0.47± 0.02	-	S	S	NS	**Gupta *et al.* (1986)**
HF X Sahiwal	NDRI	312 ± 5	0.16 ± 0.02	S	NS	S	-	**Tajane and Rai (1989)**
HF X Sahiwal	MDF	296 ± 4	0.12 ±0.03	-	-	S	-	**Jadhav *et al.* (1991)**
Frieswal	MDF	326 ± 5	-	-	S	-	-	**Arora *et al.* (1993)**
Crossbred	GBPUAT	299 ± 8	0.05 ± 0.02	-	NS	NS	-	**Singh *et al.* (1993)**
J X Kankrej	Nagpur	360 ± 11	-	-	NS	NS	-	**Tekade *et al.*(1994)**
Jersey X Sahiwal	Wadsa (MP)	309 ± 3	-	-	NS	S	-	**Deshmukh *et al*. (1995)**
HF X Dangi	MPAU	306 ± 3	-	-	NS	S	-	**Thalkari *et al.*(1995)**
KS	NDRI	328 ± 9	0.19 ± 11	NS	NS	NS	NS	**Singh (1995)**
KF	NDRI	345 ± 11	0.09 ± 0.8	NS	S	S	NS	**Singh (1995)**
KF	NDRI	343 ± 4	-	-	S	S	-	**Sivakumar (1998)**
KF	NDRI	346 ± 5	-	-	NS	NS	-	**Sinha (1999)**
Sahiwal	Pakistan	260.52 ± 2.64	0.06 ± 0.04		S	S		**Javed *et al.* (2000)**
KF	NDRI	344 ± 6	0.13 ± 0.07	-	S	S	S	**Sahana and Gurnani (2000)**
Sahiwal	NDRI, Karnal	245.03 ± 12.18	0.44 ± 0.22					**Mohnaty (2001)**

KS	NDRI	298 ± 11	-	NS	S	S	-	**Mandal and Sachdeva (2001)**
KS	NDRI	332 ± 11	0.22 ± 0.05	NS	S	S	S	**Saha (2001)**
KF	NDRI	315 ±10	0.21 ± 0.05	NS	NS	NS	NS	**Saha (2001)**
Sahiwal	NDRI, Karnal	297.94 ± 6.84	0.23 ± 0.19		NS	NS		**Kannan (2002)**
HFXT (F1)	CCBF,Lakhimpur	312 ± 6	-	NS	NS	S	-	**Bhattacharya *et al*.(2002)**
HFXT (F2)	CCBF,Lakhimpur	248 ±19	-	NS	NS	S	-	**Bhattacharya *et al*.(2002)**
Sahiwal	NDRI, Karnal	249.08±9.44	0.48 ± 0.21		NS	S		**Kumar (2003)**
5/8HF X 3/8 SW	GBPUAT,MDF	321 ± 3	-	S	NS	NS	-	**Akhtar *et al*.(2003)**
5/8HF X 3/8 SW	GBPUAT,MDF	324 ± 3	-	S	NS	NS	-	**Akhtar *et al*.(2003)**
Frieswal	MFD	343 ± 3	-	S	S	NS	NS	**PDC AR (200304)**
Sahiwal	NDRI	296 ± 6	0.89 ± 0.24	-	NS	S	-	**Raja (2004)**
Sahiwal	GLF, Ganjaria	312.81±4.54	0.10±0.05		NS	S		**Banik (2004)**
Frieswal	MDF	324 ± 2	0.11 ± 0.03	NS	S	S	S	**Mukherjee (2005)**
Sahiwal	GBPUA&T, Pantnagar	309.23±7.29	0.09 ± 0.10	-	NS	S	-	**Singh *et al* (2005)**
KF	NDRI	359.92 ± 4.33	0.19 ± 0.11	S	NS	S	NS	**Nehra (2012)**
KF	NDRI	326.57 ± 2.60	0.11 ± 0.05	S	S	S	-	**Dash *et al.* (2016)**
Sahiwal	GBPUA&T, Pantnagar	321.60 ± 2.80	0.27 ± 0.08	S	NS	S	-	**Singh and Singh (2016)**
Sahiwal	NDRI	323.171 ± 7.22	0.16 ± 0.09	S	S	S	S	**Parveen *et al.,* (2018)**

The insignificant effect of season of calving on FLL was also found by **Raja (2004)** in Sahiwal, **Nehra *et al.* (2013)** in Karan fries and **Singh and Singh (2016**) in Sahiwal cattle. However, significant effect of season was reported by **Parveen *et al.* (2018)** in Sahiwal cattle, **Mukherjee (2005)** in Frieswal cattle and **Saha (2001)** in Karan swiss cattle.

2.1.3.3 Heritability

The heritability estimates of FLL in Sahiwal and crossbred cattle varied from 0.06 ± 0.04 **(Javed *et al.,* 2000)** to 0.88 ± 0.24 **(Raja, 2004)** and 0.05 ± 0.02 **(Singh *et al.,* 1993)** to 0.47 ± 0.02 **(Gupta *et al.,* 1986)**, respectively**.** The heritability as reported by various workers has been presented in Table 2.1.3.

2.1.3.4 Genetic and phenotypic correlation

Gandhi and Gurnani (1988) observed highly significant (P<0.01) genetic correlation between first lactation length (FLL) and age at first calving**.** The genetic correlation between these two traits varied from -0.525 **(Singhal *et al.*, 1994)** to 1 **(Singh 1992).**

The genetic correlation between FLL and FCI varied from 0.35 ± 0.08 **(Tomar *et al.*, 1996)** to 1 **(Rao, 1985**). **Singh (1986)** found highly significant (P < 0.01) phenotypic correlation (0.530 ± 0.024) between these two traits.

The genetic correlations between FLL and FDP were reported to be ranging from -0.865 ± 0.162 **(Kumar, 2003)** to 1 **(Mohanty, 2001; Kannan, 2002).** The phenotypic correlations between these two traits varied from -0.447 ± 0.067 **(Mohanty, 2001)** to -0.172 ± 0.047 **(Singh *et al.*, 1999).**

The genetic correlations between FLL and FSP varied from -0.238 ± 0.599 **(Kannan, 2002)** to 0.429 ± 0.359 **(Kumar, 2003)**.

The genetic correlations between FLL and FSP, FDP and FCI were reported as 0.79 ± 0.14, 0.12 ± 0.33 and 0.73 ± 0.17 in Frieswal cattle **(Mukherjee, 2005)**.

2.1.4. Age at First Calving (AFC)

The mean, heritability and factors affecting the AFC in Sahiwal and crossbred cows as reports by different authors have been summarized in Table 2.1.4.

2.1.4.1 General performance

The average AFC in Sahiwal and crossbred cattle varied from 1098 ± 80 days **(Raja, 2004)** to 1567.64 ± 20.06 days **(Kuralkar *et al.,* 1996)** and 859 ± 5 days **(Nagore and Kulkarni, 2000)** 1321.82 ± 10.83 days **(Dubey and Singh 2005),** respectively.

2.1.4.2 Genetic and non-genetic factors affecting AFC

Significant effect of sire on AFC was observed by **Mukherjee (2005)** in Frieswal, **Saha (2001)** and **Nehra *et al.* (2013)** in KF cattle and **Singh and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle. However, insignificant effect was found by **Singh and Dubey (2005)** in crossbred and Sahiwal cattle.

The significant effect of period of birth on AFC was found by **Mukherjee (2005)** in Frieswal, **Singh and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle. However, insignificant effect was found by **Raja (2004)** in Sahiwal.

The insignificant effect of season on AFC was reported by **Sinha (1999) and Nehra *et al.* (2013)** in KF cattle, **Mukherjee (2005)** in Frieswal, **Singh and Dubey (2005)** in crossbred and Sahiwal cattle and **Singh *et al.* (2015)** in Sahiwal cattle.

2.1.4.3 Heritability

The heritability estimates studied for AFC varied from 0.02 ± 0.02 **(Rehman *et al.*, 2008)** to 0.45 ± 0.14 **(Parveen *et al.,* 2018)** in Sahiwal cattle and 0.11 ± 0.02 (**Arora *et al.* (1993)** 0.86 ± 0.21 (**Singh, 1995**) in crossbred as summarized in table 2.1.4.

2.1.4.4 Genetic and phenotypic correlation

The highest (0.63) genetic correlation between AFC and FLMY was identified by **Ahmad *et al.* (2001),** whereas near to zero and insignificant (-0.03) genetic correlation between both the trait was reported by **Tomar *et al.* (1974).** The range of genetic and phenotypic correlation between these two traits was -0.710 ± 0.084 **(Singh, 1992)** to 0.60 **(Tomar *et al.* (1974))** and -0.26 **(Ahmad *et al.*, 2001)** to 0.098 ± 0.029 **(Singh, 1986),** respectively.

The first service period showed a highly positive genetic correlation with age at first calving of 0.609 ± 0.273 as observed by **Singh *et al.* (1999),** while **Kumar (2003)** studied lowest value of 0.064 ± 0.44 in Sahiwal cattle. The phenotypic correlation between these two traits was observed to be very low 0.059 ± 0.049 **(Singh *et al.*, 1999).**

Table 2.1.4 Means, heritability and factors affecting the age at first calving (days) in Sahiwal and crossbred cattle

Breed	Location	Mean ± S.E.	Heritability (h^2 ± SE)	Effect of			References
				Sire	Season	Period	
1	2	3	4	5	6	7	8
Sahiwal	NDRI	1147.90	0.17 ± 0.10	-	-	S	**Reddy (1983)**
BS X Tharparkar	NDRI	927 ± 19	0.29 ± 0.13	-	S	S	**Kumar (1986)**
Frieswal	MDF	875 ± 9	0.11± 0.02	-	-	-	**Arora *et al.* (1993)**
KS	NDRI	1009 ±19	0.82 ±0.21	S	NS	NS	**Singh (1995)**
KF	NDRI	978 ± 10	0.86±0.21	S	NS	S	**Singh (1995)**
Sahiwal	Nagpur	1567.64 ± 20.06					**Kuralkar *et al.* (1996)**
KF	NDRI	940 ± 18	0.36 ± 0.19	S	S	S	**Panja (1997)**
KF	NDRI	985 ± 5	-	-	NS	S	**Sivakumar (1998)**
KF	NDRI	985 ± 16	-	-	NS	NS	**Sinha (1999)**
Sahiwal	Pakistan	1321.00	-	-	-	-	**Khan *et al.* (1999)**
KF	NDRI	969 ± 6	-	-	NS	S	**Sahana and Gurnani (2000)**
Gir cross	MPKVV, Rahuri	859 ± 5	-	-	-	-	**Nagore and Kulkarni (2000)**
Crossbred	-	1168 ± 11	-	-	-	-	**Rao *et a*l. (2000)**
KS	NDRI	1047 ± 17	0.17 ± 0.05	S	NS	S	**Saha (2001)**
KF	NDRI	1009 ± 14	0.17 ± 0.09	S	NS	S	**Saha (2001)**
5/8HF X 3/8 SW	GBPUAT,MDF	1071 ±14	-	S	S	S	**Akhtar *et al*.(2003)**
5/8HF X 3/8 SW	GBPUAT,MDF	1038 ± 14	-	S	S	S	**Akhtar *et al*.(2003)**
Frieswal	MDF	1005 ± 11	0.10 ± 0.02	-	S	NS	**PDC AR, 2003-04**
Sahiwal	NDRI	1098 ± 8	0.26 ± 0.23	-	NS	S	**Raja (2004)**
Frieswal	MDF	972 ± 4	0.23 ± 0.04	S	S	NS	**Mukherjee (2005)**
Crossbred and Sahiwal		1321.82 ± 10.83	0.28 0.08	NS	S	NS	**Dubey & Singh (2005)**
Sahiwal	GBPUA&T, Pantnagar	1103.76 ± 23.78	0.41 ± 0.17	-	NS	S	**Singh *et al*. (2005)**
Sahiwal	Pakistan	1390.00 ± 3.90	0.02 ± 0.02	-	S	-	**Rehman *et al.* (2008)**
KF	NDRI	1006 ± 8	0.43 ± 0.13	S	NS	NS	**Nehra (2012)**
Sahiwal	NDRI	1111.26 ± 9.98	0.11 ± 0.07		NS	S	**Manoj (2009)**
Sahiwal	GBPUA&T, Pantnagar	1287.12 ± 6.81	0.39 ± 0.16	S	NS	S	**Singh and Singh (2016)**
Sahiwal	NDRI	1114.21 ± 9.14	0.45 ± 0.14	S	S	S	**Parveen *et al.*, (2018)**

Mukherjee (2005) found that the AFC had positive genetic correlations with the other first lactation traits viz., FLMY (0.24 ± 0.15), FL305DMY (0.22 ± 0.14), FLL (0.17 ± 0.16), FSP (0.26 ± 0.20), FDP (0.34 ± 0.21) and FCI (0.35 ± 0.17) in Frieswal cattle. Phenotypic correlations of AFC with other first lactation traits were generally low ranging from 0.01 ± 0.02 for FSP to 0.12 ± 0.02 for FL305DMY.

2.1.5. First Calving Interval (FCI)

The mean, heritability and factors affecting the FCI in Sahiwal and crossbred cows as reports by different workers have been summarized in Table 2.1.5.

2.1.5.1 General performance

The estimates of average first calving interval reported by various workers in Sahiwal and crossbred cattle varied from 309.23 ± 7.29 days **(Singh *et al.*, 2005)** to 514.86 ± 4.82 days **(Singh and Singh, 2016)** and 359.92 ± 4.33 days **(Nehra, 2012)** to 551.0 ± 173days **(Yadav *et al.,* 2004)**, respectively, (Table 2.5).

2.1.5.2 Genetic and non-genetic factors affecting FCI

Significant effect of sire on FCI was observed by **Hammoud *et al.* (2010)** in Holstein crossbred cattle and **Parveen *et al.* (2018)** in Sahiwal. However, the non-significant effect was found by **Saha (2001)** and **Nehra *et al.* (2013)** in KF cattle, **Raja (2004)** in Sahiwal and **Mukherjee (2005)** in Frieswal.

Significant effect of period on FCI was observed by **Mukherjee (2005)** in Frieswal, **Saha (2001)** and **Nehra *et al.* (2013)** in KF cattle and **Raja (2004)** and **Parveen *et al.* (2018)** in Sahiwal. However, the insignificant effect was found by **Saha (2001)** in KF and **Akhtar *et al.* (2003)** in HF crosses.

The insignificant effect of season on FCI was reported by **Singh (1995)** and **Saha (2001)** in KS cattle, **Nehra *et al.* (2013)** in KF cattle and **Raja (2004)** in Sahiwal.

2.1.5.3 Heritability

The range of heritability estimates of first calving interval as observed by different authors was 0.09 ± 0.10 **(Singh *et al.,* 2005)** to 0.31 ± 0.15 **(Singh, 1992)** in Sahiwal and 0.03 ± 0.05 **(Saha, 2001)** to 0.25 ± 0.44 **(Raja, 2004)** in crossbred cattle.

Table 2.1.5 Means, heritability and factors affecting the first calving interval (days) in Sahiwal and crossbred cattle

Breed	Location	Mean ± S.E.	Heritability (h^2 ± SE)	Effect of				References
				Sire	Season	Period	AFC	
1	2	3	4	5	6	7	8	9
HF /BS /J X O	Lam (AP)	451 ± 8	-	-	-	-	-	**Kumar *et al.* (1991)**
Sahiwal	NDRI, Karnal	479.21 ± 6.22	0.31 ± 0.14	-	NS	S	-	**Singh (1992)**
Sahiwal	GLF, Hissar	507.82 ± 7.14	0.31 ± 0.15					**Singh (1992)**
HF X H	MDF	482 ± 3	-	-	S	S	-	**Raheja *et al.* (1994)**
J X S	Wadsa (MP)	452 ± 8	-	-	NS	NS	-	**Chaudhary *et al*. (1995)**
KS	NDRI	425 ± 13	0.05 ± 0.01	NS	NS	NS	NS	**Singh (1995)**
KF	NDRI	423 ± 11	0.02 ± 0.08	NS	S	S	NS	**Singh (1995)**
KF	NDRI	405 ± 4	0.02 ± 0.14	NS	S	NS	NS	**Panja (1997)**
KF	NDRI	413 ± 4	-	-	S	S	-	**Sivakumar (1998)**
KF	NDRI	407 ± 6	-	-	S	S	S	**Sahana and Gurnani (2000)**
Gir cross	MPKVV, Rahuri	414 ± 2	-	-	-	-	-	**Nagore and Kulkarni (2000)**
KS	NDRI	430.33 ± 12	0.03 ± 0.05	NS	NS	S	NS	**Saha (2001)**
KF	NDRI	423± 13	0.35 ± 0.10	NS	S	NS	NS	**Saha (2001)**
5/8HF X 3/8 SW	GBPUAT,MDF	386.68 ± 7	-	NS	S	NS	-	**Akhtar *et al*.(2003)**
5/8HF X 3/8 SW	GBPUAT,MDF	393.36 ± 3	-	NS	S	NS	-	**Akhtar *et al*.(2003)**
Crossbred	Mathura	551.0 ± 173	-	-	-	-	-	**Yadav *et al.*(2004)**
Sahiwal	NDRI	430.23 ± 9	0.25 ± 0.44	-	NS	S	-	**Raja (2004)**
Sahiwal	Karnal, GLF, Ganjaria	480.57±5.73	0.13 ± 0.06	-	S	S	-	**Banik (2004)**
Frieswal	MDF	421 ± 9.8	0.06 ± 0.03	NS	S	S	-	**Mukherjee (2005)**
Sahiwal	GBPUA&T, Pantnagar	309.23 ± 7.29	0.09 ± 0.10	-	NS	S	-	**Singh et al (2005)**
Friesian	Egypt	403.1 ± 1.9	-	S	S	S	NS	**Hammoud *et al.* (2010)**
KF	NDRI	359.92 ± 4.33	0.19 ± 0.11	S	NS	S	NS	**Nehra (2012)**
Sahiwal	GBPUA&T, Pantnagar	514.86 ± 4.82	0.10±0.10	S	NS	S	NS	**Singh and Singh (2016)**
Sahiwal	NDRI	323.171±7.22	0.16±0.09	S	S	S	NS	**Parveen *et al.* (2018)**

2.1.5.4 Genetic and phenotypic correlation

The range of genetic and phenotypic correlations between FCI and FDP was 0.57 ± 0.19 **(Tomar *et al.*, 1996)** to 0.78 ± 0.156 **(Singh *et al.*, 1999)** and 0.32 ± 0.08 **(Tomar *et al.*, 1996)** to 0.826 ± 0.026 **(Singh *et al.*, 1999),** respectively.

2.1.6 First Dry Period (FDP)

The mean, heritability and factors affecting the FDP in Sahiwal and crossbred cattle as observed by different authors have been summarized in Table 2.1.6.

2.1.6.1 General performance

The average of first dry period observed by different authors in Sahiwal and crossbred cattle varied from 126.25 ± 7.77 days **(Raja, 2004)** to 221.68 ± 5.20 days **(Javed *et al.,* 2000)** and 61.00 ± 2.00 days in KF **(Singh and Tomar,1991)** to 147 days in Frieswal cattle **(PDC, AR, 2008 2009)**, respectively.

2.1.6.2 Genetic and non-genetic factors affecting FDP

Significant effect of sire on FDP was reported by **Saha (2001)** in KF cattle, **Akhtar *et al.* (2003)** in HF crosses, but the non-significant effect of sire on FDP was found by **Singh (1995)** and **Panja (1997)** in KF cattle and **Mukherjee (2005)** in Frieswal.

The insignificant effect of period on FDP was observed by **Sahana and Gurnani (2000), Saha (2001)** and **Saha *et al.* (2010)** in KF cattle and **Chawla and Mishra (1982)** in Sahiwal cattle. However **(Akhtar *et al.* 200)** in HF crosses and **Raja (2004)** in Sahiwal found significant effect.

The insignificant effect of season on FCI was also found by **Sahana and Gurnani (2000), Saha (2001)** and **Singh and Gurnani (2004)** in KF cattle and **Rehman *et al.* (2006)** and **Zafar *et al.* (2008)** in Sahiwal cattle. However, **Mukherjee (2005)** and **Saha *et al.* (2010)** found significant effect.

The insignificant effect of AFC groups on FDP was studied by **Panja (1997), Sahana and Gurnani (2000)** and **Saha (2001)** in KF cattle, while **Mukherjee (2005)** observed the significant effect.

Table 2.1.6 Means, heritability and factors affecting the first dry period (days) in Sahiwal and crossbred cattle

Breed	Mean ± SE (days)	Heritability (h^2 ± SE)	Effect of				References
			Sire	Season	Period	AFC	
Sahiwal	134.60 ± 4.90	-		NS	NS		**Chawla and Mishra (1982)**
KF	61.00 ± 2.00	0.10 ± 0.13	-	NS	-	-	**Singh and Tomar (1991)**
Sahiwal	192.40	0.121 ± 0.04	-	-	-	-	**Khan *et al.* (1992)**
KF	75.44 ± 5.76		NS	NS	-	-	**Singh (1995)**
HF X H	106.00 ± 8.70		-	S	-	-	**Nayak and Raheja (1996)**
KF	64.47 ± 1.46	0.11 ± 0.15	NS	NS	NS	NS	**Panja (1997)**
Sahiwal	221.68 ± 5.20	0.03 ± 0.03	-	NS	S	-	**Javed *et al.* (2000)**
KF	65.09 ± 2.95		-	NS	NS	NS	**Sahana and Gurnani (2000)**
Sahiwal	178.73 ± 12.56	0.12 ± 0.23	-	S	NS	-	**Mohanty (2001)**
KF	81.72 ± 5.96	0.13 ± 0.09	S	NS	NS	NS	**Saha (2001)**
5/8 HFX3/8 SW	65.31 ± 2.69	-	S	S	S	-	**Akhtar *et al.* 2003**
Frieswal	-	0.43 ± 0.19	-	-	-	-	**Gaur (2003)**
Sahiwal	126.25 ± 7.77	0.23 ± 0.14	-	NS	S	-	**Raja (2004)**
KF	75.00 ± 6.00	-		NS	NS	-	**Singh and Gurnani, 2004**
Frieswal	115.64 ± 1.86	0.06 ± 0.03	NS	S	S	S	**Mukherjee (2005)**
Sahiwal	244 ± 2.8	0.05 ± 0.02	-	NS	S	-	**Rehman *et al.* (2006)**
Frieswal	147		-	-	-	-	**PDC AR (2008-09)**
Sahiwal	-	-	-	NS	S	-	**Zafar *et al*. (2008**
KF	80.72 ± 5.96			S	NS	-	**Saha *et al.* (2010)**

2.1.6.3 Heritability

The heritability studied of first dry period found by numerous authors were varied from 0.03 ± 0.03 **(Javed *et al.*, 2000)** to 0.23 ± 0.14 **(Raja, 2004)** in Sahiwal and 0.06 ± 0.03 (**Mukherjee, 2005)** to 0.43 ± 0.19 **(Gaur, 2003)** in crossbred, as listed in Table 2.1.6.

2.1.6.4 Genetic and phenotypic correlation

Bhatnagar *et al.* (1983) observed very high (0.673) phenotypic correlation of FDP with FSP**,** but the genetic correlation between these two traits was observed moderate and non-significant **(Pundir and Raheja, 1995).** The genetic correlation of FDP with FSP varied from -0.604 ± 0.255 **(Kannan, 2002)** to 1 **(Mohanty, 2001),** while the phenotypic correlation between these two traits varied from -0.442 ± 0.068 **(Mohanty, 2001)** to 0.86 ± 0.34 **(Pundir and Raheja, 1995).**

The genetic correlation between FDP and FSP was reported to be 0.72 ± 0.19 by **Mukherjee (2005).** FDP had the lowest phenotypic correlation with FL305DMY (0.06 ± 0.02) while it had the maximum correlation with FCI (0.80 ± 0.01).

2.1.7. First Service Period (FSP)

The mean, heritability and factors affecting the FDP in Sahiwal and crossbred cattle as reports by different authors have been summarized in Table 2.1.7.

2.1.7.1 General performance

The average values of the first service period varied from 143.32 ± 8.21 days **(Raja 2004)** to 228.95 ± 0.46 days **(Kathiravan *et al.*, 2009)** in Sahiwal and 115.53 ± 2.50 days in HF X Sahiwal crossbred **(Pyne and Dattagupta 1994)** to 187 days in Frieswal cattle **(PDC – Annual Report 2010-11**).

2.1.7.2 Genetic and non-genetic factors affecting FSP

Significant effect of sire on FSP was also observed by **Hammoud *et al.* (2010)** in Holstein crossbred cattle and **Dash *et al.* (2016)** in Karan fries. However, the not significant effect was found by **Panja (1997), Sahana and Gurnani (2000)** and **Saha (2001)** in KF cattle.

Table 2.1.7 Means, heritability and factors affecting the first service period (days) in Sahiwal and crossbred cattle

Breed	Mean ± SE (days)	Heritability (h^2 ± SE)	Effect of				References
			Sire	Season	Period	AFC	
Sahiwal	177.50	-	-	NS	S	-	**Reddy (1983)**
HF X SW	169.50 ± 6.43		NS	-	NS	-	**Bhatia and Pandey (1990)**
KF	137.61 ± 5.03	0.036 ± 0.12	-	-	-	-	**Singh and Tomar (1991)**
Frieswal	175.00 ± 12.84		-	S	-	-	**Arora *et al.* (1993)**
HF X SW	115.53 ± 2.50		-	-	-	-	**Pyne and Dattagupta (1994)**
KF	142.90 ± 10.82		NS	NS	NS	-	**Singh (1995)**
KF	127.50 ± 6.09		NS	S	S	S	**Sahana (1996)**
KF	124.24 ± 3.83	0.046 ± 0.14	NS	S	S	NS	**Panja (1997)**
KF	127.69 ± 11.27	0.16 ± 0.75	NS	S	NS	NS	**Saha (2001)**
Frieswal	-	0.49 ± 0.21	-	-	-	-	**Gaur (2003)**
Frieswal	164.51 ± 2.51	0.06 ± 0.03	NS	S	S	S	**Mukherjee (2005)**
Sahiwal (NDRI)	155.16 ± 9.97	0.05 ± 0.12	-	NS	NS	-	**Banik (2004**
Sahiwal (Ganjaria)	249.22 ± 7.12	0.14 ± 0.06	-	S	S	-	**Banik (2004**
Sahiwal	143.32 ± 8.21	0.27 ± 0.15	-	NS	S	-	**Raja (2004**
Sahiwal	159 ± 1.56	-	-	S	NS	-	**Zafar *et al.* (2008)**
Sahiwal	178.00 ± 3.10	0.04 ± 0.02		S	S	-	**Rehman *et al.* (2008)**
Sahiwal	228.95 ± 0.46		-	NS	NS	-	**Kathiravan *et al.* (2009)**
Frieswal	187		-	-	-	-	**(PDC AR 2010-11)**
KF	130 ± 3		-	NS	S	NS	**Divya (2012)**
Sahiwal	231.34 ± 4.88	0.15 ± 0.10	S	NS	S	NS	**Singh and Singh (2016)**

The insignificant effect of period on FSP was also reported by **Bhatia and Pandey (1990)** in HF crosses **Singh (1995)** and **Saha (2001)** in KF cattle and **Kathiravan *et al.* (2009)** in Sahiwal. However, the significant effect was observed by **Rehman *et al.* (2008)** in Sahiwal and **Mukherjee (2005)** in Frieswal.

The insignificant effect of season on FSP was also found by **Singh (1995)** and **Divya (2012)** in KF cattle and **Zafar et al. (2008)** and **Kathiravan et al. (2009)** in Sahiwal cattle. However, the significant effect was observed by **Rehman *et al.* (2008)** in Sahiwal and **Mukherjee (2005)** in Frieswal.

The insignificant effect of AFC groups on FSP was also found by **Panja (1997), Singh (1995)** and **Divya (2012)** in KF catlle. However, the significant effect was observed by **Mukherjee (2005)** in Frieswal.

2.1.7.3 Heritability

The heritability reported for first service period by various authors were varied from 0.04 ± 0.02 **(Rehman *et al.*, 2008)** 0.27 ± 0.15 **(Raja, 2004)** in Sahiwal and 0.036 **±** 0.12 **(Singh and Tomar, 1991)** to 0.49 ± 0.21 **(Gaur, 2003)** in crossbred cattle.

2.1.7.4 Genetic and phenotypic correlation

Bhatnagar *et al.* (1983) observed very high (0.673) phenotypic correlation of FSP with FDP**,** but the genetic correlation between these two traits was observed moderate and not significant **(Pundir and Raheja, 1995).** The genetic correlation of FDP with FSP varied from -0.604 ± 0.255 **(Kannan, 2002)** to 1 **(Mohanty, 2001),** while the phenotypic correlation between these two traits varied from -0.442 ± 0.068 **(Mohanty, 2001)** to 0.86 ± 0.34 **(Pundhir and Raheja, 1995).**

2.1.8 First Lactation Milk Yield per Day of First Lactation Length (FLMY/FLL)

2.1.8.1 General performance

Singh and Gurnani (2004) and **Nehra (2012)** reported the first lactation milk yield per day of first lactation length as 10.60 and 9.04 kg, respectively.

2.1.8.2 Genetic and non-genetic factors affecting FLMY/FLL

Singh and Gurnani (2004) and **Nehra (2012)** observed the significant effect of sire and period of calving, while the insignificant effect of season on FLMY/FLL was observed by **Nehra (2012).**

2.1.8.3 Heritability

Nehra (2012) reported the heritability estimate of first lactation milk yield per day of first lactation length as 0.61 ± 0.15, while **Dash (2014)** reported an estimate of 0.40 ± 0.09.

2.1.8.4 Genetic and phenotypic correlation

Nehra (2012) estimated the genetic correlations of FLMY/FLL with FL305DMY, FLMY, FLL, AFC, and FCI as 0.99 ± 0.02, 0.85 ± 0.09, 0.12 ± 0.29, - 0.08 ± 0.19 and -0.26 ± 0.39, respectively and phenotypic correlation as 0.88 ± 0.04, 0.65 ± 0.11, - 0.06 ± 0.31, 0.09 ± 0.15 and -0.13 ± 0.40, respectively.

2.1.9 First Lactation Milk Yield per Day of First Calving Interval (FLMY/FCI)

2.1.9.1 General performance

Singh and Gurnani (2004) and **Nehra (2012**) reported the first lactation milk yield per day of first calving interval as 8.90 and 5.44 kg, in HF cross and KF cattle, respectively.

2.1.9.2 Genetic and non-genetic factors affecting FLMY/FCI

Nehra (2012) reported the significant effect of sire, while the insignificant effect of season and period on FLMY/FCI. **Singh and Gurnani (2004)** also reported the significant effect of sire on FLMY/FCI.

2.1.9.3 Heritability

The heritability estimates for first lactation milk yield per day of calving interval was reported as 0.61 ± 0.15 and 0.44 ± 0.10 by **Nehra (2012)** and **Dash (2014)**, respectively.

2.1.9.4 Genetic and phenotypic correlation

Nehra (2012) estimated the genetic correlations of FLMY/FCI with FL305DMY, FLMY, FLL, AFC, and FCI as 0.99 ± 0.03, 0.8 ± 0.08, 0.20 ± 0.29, -0.13 ± 0.19 and -0.22 ± 0.40, respectively and the phenotypic correlations for these traits were reported as 0.84 ± 0.05, 0.68 ± 0.09, 0.06 ± 0.30, 0.08 ± 0.18 and -0.26 ± 0.41, respectively.

2.2. Genetic and Phenotypic Trends of Production and Reproduction Traits

The literatures available on genetic and phenotypic trends of different production and reproduction traits in cattle have been reviewed under following headings.

2.2.1. First Lactation 305 Days milk yield (FL305DMY)

The Table 2.2.1 summarizes the genetic and phenotypic trends of FL305DMY.

Herbert (1987) in Karan Swiss, **Raja (2004)** in Sahiwal and **Nehra (2012)** in KF estimated the genetic trends by Smith method I as 73.15 ± 0.50, 13.72 ± 9.25 and 19.00 ± 36.00 kg, respectively while **Mukherjee (2005)** reported genetic trends in Frieswal cattle at Meerut and Ambala farm by Smith method I as 34.24 ± 35.26 and -1.77 ± 37.45 kg and the corresponding estimates by Smith method II as -21.73 ± 33.68 and 3.75 ± 40.92 kg, respectively.

The phenotypic trends for FL305DMY were estimated by **Herbert (1987)** in Karan Swiss cattle, **Raheja (1994)** in Hariana cattle, **Raja (2004)** in Sahiwal cattle and **Nehra (2012)** in KF cattle as 48.27 ± 7.10, 3.68 ± 3.81, -26.90 ± 7.45 and 20.74 ± 6.08 kg, respectively. **Mukherjee (2005)** reported the phenotypic trends in Frieswal cattle maintained Meerut and Ambala farms as 19.75 ± 4.73 and 20.54 ± 5.96 kg, respectively.

Topanurak *et al*. (2001) found that the phenotypic trend for FL305DMY was greater than the genetic trend due to the enhancement in environmental conditions such as nutrition, management and health and a negative genetic trend of 17.05 kg/year due to farmers' unwillingness to sacrifice low-yielding cows either because of a emotional link or due to poor judgment, it was due to a lack of solid information about the actual genetic potential of the cow.

Bakir and Kaygisiz (2009) reported that phenotypic, genetic and environmental trends for lactation length and 305 days milk yield were -0.486 days / year and -23.59 kg / year, -0.49 days/year and 7.99 kg/year, -0.976 days/year and -31.58 kg/year, respectively, in Holstein-Friesian cattle.

Sarakul *et al.* (2011) reported genetic trends for 305-d milk yields as -1.47 ± 1.89 kg/year for sires, 0.29 ± 1.02 kg/yr for cattle, and 1.44 ± 0.91 kg/yr for dams from 1990 to 2007. The phenotypic trend for milk yield for this period was 14.57 ± 10.63 kg/yr.

Dash *et al*. (2016) studied the genetic trend in the production traits of Holstein Friesian crossbred cattle. Significant phenotypic trend obtained for FL305DMY 18.71 ± 8.37 kg\year and the genetic trend was 0.10 ± 2.13 kg\year.

Parveen *et al.* (2018) estimated genetic and phenotypic trends for FL305DMY in Sahiwal as 1.72 ± 0.50 and -19.85 ± 2.17 kg/year, respectively. The genetic and phenotypic trends were positive and significant.

Table 2.2.1 Annual Genetic and phenotypic trends for first lactation 305 days milk yield (kg)

Breed	Study site	Method	ΔG(Genetic trend)	ΔP(Phenotypic trend)	References
Kankrej	Mandavi, Gujarat	Smith II	72.26 ± 19.24	18.84 ± 11.62	**Des Raj (1987)**
Kankrej	Thane, maharastra	Smith II	587.99 ± 20.91	41.81 ± 10.78	**Des Raj (1987)**
KS	NDRI, karnal	Smith II	- 5.01 ± 9.53	0.58 ± 0.09	**Herbert and Bhatnagar (1988)**
Hariana	Babugarh	BULP	0.82 ± 0.26	3.68 ± 3.81	**Raheja (1993)**
Sahiwal	Lucknow, UP	BULP	5.04 ± 0.48	13.08 ± 3.94	**Raheja (1993)**
Kankrej	Chharodi	Smith II	- 0.88 ± 0.26	3.68 ± 3.81	**Chaudhary *et al.*(1994)**
KF	NDRI, Karnal	Smith II	-110.00±51.57	-11.51 ± 10.76	**Singh (1995)**
KS	NDRI, Karnal	Smith II	2.60 ± 101.2	14.00 ± 14.39	**Singh (1995)**
Sahiwal	NDRI, Karnal	Smith I	13.72 ± 9.25	- 26.90 ± 7.45	**Raja (2004)**
Sahiwal	NDRI, Karnal I	Smith II	65.51 ± 39.29	- 26.90 ± 7.45	**Raja (2004)**
Frieswal	MDF	Smith I	34.24 ± 35.36	19.75 ± 4.73	**Mukherjee (2005)**
Sahiwal	Pakistan	BLUP	-3.7	0.1	**Rehman *et al.* (2008)**
Brown Swiss	Konya farm Turkey	Holland	-78	135	**Kaygisiz (2010)**
Thailand breed	Thailand	-	0.29 ± 1.02	14.57 ± 10.63	**Sarakul *et al.* (2011)**
Holstein Friesian	Ludhiana	BLUP	18.71 ± 8.37	0.10 ± 2.13	**Dash *et al*. (2016)**
Sahiwal	NDRI	BLUP	1.72 ± 0.50	-19.85 ± 2.17	**Parveen *et al.* (2018)**

2.2.2. First lactation milk yield (FLMY)

The duration of lactation of crossbred animals is generally longer than the standard FL305DMY. This condition seems to be more obvious in the case of very high producers, since their period of service tends to be longer and, therefore, the lactation length and calving interval would be high. The genetic and phenotypic tendencies of FLMY are summarized in Table 2.2.2.

Table 2.2.2 Annual genetic and phenotypic trends for first lactation milk yield (kg)

Breed	Study site	Method	ΔG(Genetic trend)	ΔP(Phenotypic trend)	References
Jersey	SCF	Smith II	139.80 ± 60.33	18.05 ± 8.85	**Murdia and Tripathi (1986)**
HF	Hisar, Hariyana	-	-19.57 ± 17.77	204.72	**Sadana and Tripathi (1986)**
RS	CCFB, Chiplima	Smith II	102.50 ± 56.00	- 83.00 ± 13.00	**Gupta (1992)**
RS	Gourikarma	Smith II	58.71 ± 26.00	- 76.00 ± 26.00	**Gupta (1992)**
RS	Hosur	Smith II	- 37.55 ± 17.00	29.00 ± 17.00	**Gupta (1992)**
RS	Puddukkottai	Smith II	- 41.87 ± 26	11.40 ± 26.00	**Gupta(1992)**
KF	NDRI, Karnal	Smith II	-153.40 ± 76.2	- 27.0 ± 15.67	**Singh (1995)**
KS	NDRI, Karnal	Smith II	67.12 ± 150.20	12.95 ± 20.75	**Singh (1995)**
Sahiwal	Durg	Smith I	-104.18 ± 61.2	44.53 ± 6.76	**Singh and Nagarcenkar (2000)**
Sahiwal	Durg	Smith II	- 87.77 ± 60.43	-	**Singh and Nagarcenkar (2000)**
Sahiwal	Meerut	Smith I	10.08 ± 31.79	2.20 ± 4.20	**Singh and Nagarcenkar (2000)**
Sahiwal	NDRI	Smith II	77.05 ± 10.53	- 31.36 ± 9.41	**Raja (2004)**
Frieswal	MDF	BLUP	14.80	- 39.34	**Gaur (2003)**
Frieswal	Meerut	LSMBL	-16.72 ± 7.37	-1.66 ± 2.52	**Mukherjee (2005)**
Frieswal	Lucknow	LSMBL	- 47.16 ± 9.92	0.39 ± 2.73	**Mukherjee (2005)**
KF	NDRI	BLUP	3.44 ± 2.60	34.04 ± 8.62	**Nehara (2012)**
Crossbred	Hisar	Smith I	152.71 ± 18.35	-4.32 ± 4.40	**Chaudhari *et al.* (2014)**
Sahiwal	NDRI	BLUP	2.08 ± 0.68	-26.06 ± 2.4	**Parveen *et al.* (2018)**

Hansen (2000) estimated that annual genetic trends for milk yield in HF cattle had accelerated over time and averaged 37 kg in the 1960s, 79 kg in the 1970s, 102 kg in the decade of 1980 and 116 kg from 1990 to 1996.

Singh and Nagarcenkar (2000) found the phenotypic change rate was negative in larger herds and there was a positive change in small and medium herds for FLMY. It was found that genetic trend showing a boost in milk production.

Nehara (2012) estimated the phenotypic, genetic and environmental trends of economic traits. The phenotypic trends were estimated as 34.0 ± 8.62 kg, 0.05 ± 0.04 and 0.06 ± 0.02 kg for FLMY, FLMY\FCI and FLMY\FLL, respectively.

Singh *et al.* (2017) evaluated the effect of genetic and non-genetic sources of variations on lactation yield in Sahiwal cows maintained at Uttar Pradesh Livestock-cum- Agriculture Farm, Chak Ganjaria, Lucknow, (U.P.) Genetic, phenotypic and environmental trends for lactation yield were -4.46, -116.26 and -111.80, respectively.

Parveen *et al.* (2018) estimated genetic and phenotypic trends of First lactation total milk yield (FLMY) 2.08 ± 0.68 and -26.06 ± 2.4, respectively in Sahiwal cattle, maintained at NDRI, Karnal, (1962-2015). Genetic trends were positive, significant and in a desirable direction.

2.2.3. First lactation length (FLL)

The estimates of genetic and phenotypic trends of FLL have been summarized in Table 2.2.3.

Singh and Nagarcenkar (2000) reported the genetic and phenotypic trends using Smith I in Sahiwal cattle as -104.18 ± 61.20 kg and 44.53 ± 6.76 kg, respectively.

Singh *et al.* (2002) in Hariana breed reported the genetic trend by Smith I method as 2.48 ± 6.41 days while **Rehman *et al.* (2008)** and **Rehman and Khan (2012)** estimated in Sahiwal cattle by BLUP method as 0.20 and 0.13 days, respectively.

Gaur (2003) observed the genetic trend by BLUP method in Frieswal cattle as 15 kg and the phenotypic trend estimated by LRM as -39 kg. It was observed that genetic trends for most of the production traits were positive and trends for reproduction were negative, revealing a desirable improvement in performance traits over time.

Mukherjee (2005) estimated genetic trend by Smith I method in Meerut and Ambala farms as 6.35 ± 2.90 and 5.22 ± 3.81 days, respectively while the respective estimates by Smith II method as -1.83 ± 2.85 and -4.50 ± 4.27 days in Frieswal cattle and the phenotypic trend in Frieswal cattle at Meerut and Ambala farms as -1.23 ± 0.39 and -4.19 ± 0.59 days respectively.

Effa *et al.* (2011) estimated genetic and environmental trends in milk production and reproductive traits at the Agricultural Research Center Holetta" Ethiopia. Annual genetic trends were -3,384 days, -8.00 kg and -5.96 kg, -0.26 months, -0.29 months and -0.88 days, for the lactation length (LL), lactation milk yield (LMY) , milk yield adjusted (305 days MY), age at puberty (APU), age at first parturition (AFC) and calving interval (CI), respectively. The environmental trends for LMY were positive (6.717 kg) and were in the desired direction.

Chaudhari *et al.* (2014) estimated phenotypic trend for FLL was 0.95 ± 0.40 days/year. The positive genetic trend shows slight genetic improvement in the trait. Genetic trend was 4.28 ± 1.76 days/year.

Table 2.2.3 Annual genetic and phenotypic trends for first lactation length (days)

Breed	Study site	Method	ΔG(Genetic trend)	ΔP(Phenotypic trend)	References
KS	NDRI, Karnal	Smith II	4.63 ± 92	1.70 ± 0.89	**Herbert (1987)**
KS	NDRI, Karnal	Smith I	1.227 ± 7.26	2.59 ± 0.95	**Herbert (1987)**
RS	CCBF, Chiplima	Smith II	19.62	-11.08	**Gupta (1992)**
RS	Hosur	Smith II	-	- 2.02	**Gupta (1992)**
RS	Puddukottai	Smith II	- 9.78	- 2.50	**Gupta (1992)**
KS	NDRI, Karnal	Smith II	- 5.96	- 1.85 ± 1.4	**Singh (1995)**
KF	NDRI, Karnal	Smith II	1.15 ± 5.74	2.865 ± 1.114	**Singh (1995)**
Frieswal	MDF	BLUP	4.37	9.59	**Gaur (2003)**
Sahiwal	NDRI, Karnal	Smith II	-1.12 ± 0.82	-	**Raja (2004)**
Sahiwal	NDRI, Karnal	Powell II	- 0.95 ± 0.09	-	**Raja (2004)**
Frieswal	Meerut	Smith I	6.35 ± 2.90	-1.23 ± 0.39	**Mukherjee (2005)**
Frieswal	Lucknow, UP	LSMBL	- 0.77 ± 12.5	-	**Mukherjee (2005)**
Sahiwal	Pakistan	BLUP	0.2	-1.8	**Rehman *et al.* (2008)**
KF	NDRI, Karnal	BLUP	0.58 ± 0.24	1.02 ± 0.65	**Nehara (2012)**
Crossbred	Hisar	Smith I	4.28 ±1.76	0.95 ± 0.40	**Chaudhary *et al.* (2014)**

2.2.4 Age at first calving

The age at first calving is an important feature that influences the production and reproduction efficiency of an animal. It is desirable to have a lower AFC without affecting the production, breeding performance and economic performance of the animal. The lower AFC also improves the annual genetic gain by reducing the generation interval. Reports on genetic and phenotypic trends have been summarized in Table 2.2.4.

Ansari *et al*. (2009) observed a negative trend in age at first calving (decreased significantly from 30 months in 2000 to 26 months in 2005) and calving interval (435 days in 2000 and decreased to 389 days in 2004) in the Iranian Holstein Province of Fars.

Hare *et al.* (2006) observed that ages at first calving decreased over time in 5 breeds of US dairy cattle. Another study conducted in Spain also reported the decrease in the ages at first calving of the dairy population.

Vergara *et al*. (2009) observed negative trends for the annual averages of the cow for AFC and the calving interval from 1989 to 2004. In Angus-Blanco Orejinegro-Zebu, the population of cattle of multiple breeds in Colombia.

Chaudhari *et al*. (2014) studied genetic, phenotypic and environmental changes in characters of economic importance that could have taken place during the several years of selective breeding practised in the herd. Phenotypic trends were insignificant for all traits except age at first parturition, while genetic trends were in a desirable direction.

Ambhore *et al*. (2017) estimated genetic and phenotypic trends for AFC were 1.53 ± 1.27 and 9.66 ± 0.80, respectively. Phenotypic deteriorations in AFC were found in the Phule Triveni herds during the period under study.

Table 2.2.4 Annual genetic and phenotypic trends for age at first calving (days)

Breed	Study site	Method	ΔG(Genetic trend)	ΔP(Phenotypic trend)	References
Hariana	Hisar	Smith II	- 6.90	-19.80	**Acharya and Lush (1968)**
Tharparkar	NDRI, Karnal	Smith I	8.14 ± 2.41	16.58±3.01	**Gurnani (1977)**
Tharparkar	NDRI, Karnal	Smith II	3.68±3.68	2.11 ± 3.01	**Gurnani (1977)**
Hariana	SCF, UP	Smith II	22.50 ± 7.84	-	**Tomar and Singh (1981)**
Kankrej	Bhuj	Smith II	120.86 ± 39.78	2.38 ± 3.62	**Des Raj (1987)**
Kankrej	Mandavi	Smith II	148.29 ± 35.87	28.03 ± 7.54	**Des Raj (1987)**
Kankrej	Thana	Smith II	34.66 ± 52.14	9.34 ± 12.66	**Des Raj (1987)**
Jersey	SCF	Smith II	- 50.56 ± 6.94	9.13 ± 1.03	**Murdia and Tripathi (1991)**
RS	CCBF, Chiplima	Smith II	- 83.16 ± 17.64	20.33±4.21	**Gupta (1992)**
RS	Pudukottai	Smith II	- 69.32±11.48	21.68 ± 1.45	**Gupta (1992)**
RS	Gourikarma	Smith II	-16.82 ± 11.67	10.71 ± 2.56	**Gupta (1992)**
RS	Hosur	Smith II	- 64.42 ± 6.79	8.95 ± 0.75	**Gupta (1992)**
Sahiwal	NDRI, Karnal	Smith I	3.86 ± 1.00	1.05 ± 1.29	**Raja (2004)**
Sahiwal	NDRI,	Smith II	1.76 ± 0.84	-	**Raja (2004)**
Frieswal	MDF	LSMBL	- 33.71 ± 5.39	-	**Mukherjee (2005)**
Frieswal	MDF	Smith II	- 37.67 ± 3.24	5.20 ± 0.8	**Mukherjee (2005)**
Sahiwal	Pakistan	BLUP	0.21	5.5	**Rehman *et al.* (2008)**
KF	NDRI, Karnal	BLUP	-1.08 ± 2.24	2.37 ± 1.14	**Nehara (2012)**
Crossbred	Hisar	Smith I	31.27 ± 4.20	-6.34 ± 1.24	**Chaudhary *et al.* (2014)**
Phule Triveni	NDRI, Karnal	Smit II	- 45.89 ± 12.76	9.66 ± 0.80	**Ambhore *et al.* (2017)**

2.2.5. First calving interval

The calving interval is an important indicator of the reproductive efficiency of a herd. It is considered that the ideal interval of childbirth is one year with cows in milk for 300 days. To improve reproductive efficiency, profitability and faster breeding, it is desirable to have a shorter calving interval. Estimates of genetic and phenotypic trends as reported in the literature are summarized in table 2.2.5.

Table 2.2.5 Annual genetic and phenotypic trends for first calving interval (days)

Breed	Study site	Method	ΔG (Genetic trend)	ΔP(Phenotypic trend)	References
KS	NDRI	Smith I	3.79 ± 15.5	1.03 ± 1.9	**Herbert (1987)**
KS	NDRI	Smith II	41.72 ± 239.4	- 0.02 ± 0.02	**Herbert (1987)**
RS	CCBF, Chiplima	Smith II	-	- 4.77	**Gupta (1992)**
RS	Hosur	Smith II	- 16.56	3.40	**Gupta (1992)**
RS	Gourikarma	Smith II	-	5.91	**Gupta (1992)**
RS	Padukkottai	Smith II	-	4.47	**Gupta (1992)**
KS	NDRI	Smith II	15.79 ± 15	-1.29 ± 1.96	**Singh (1995)**
Frieswal	PDF	BLUP	- 11.12	-12.89	**Gaur (2003)**
Sahiwal	NDRI	Smith II	- 5.09 ± 4.087	-	**Raja (2004)**
Sahiwal	NDRI	Powell II	- 4.299±0.098	-	**Raja (2004)**
Frieswal	Meerut	Smith I	- 4.34 ± 2.67	-1.48 ± 1.33	**Mukherjee (2005)**
Frieswal	Lucknow	LSMBL	- 4.16 ± 16	-	**Mukherjee (2005)**
Sahiwal	Pakistan	BLUP	0.00001	1.2	**Rehman *et al.* (2008)**
KF	NDRI	BLUP	- 0.59 ± 1.09	1.17 ± 0.83	**Nehara (2012)**
Crossbred	Hisar	Smith I	-8.74 ± 1.90	1.83 ± 0.42	**Chaudhari *et al.* (2014)**
Phule Triveni	NDRI	BLUP	0.11 ± 0.07	0.60 ± 0.38	**Ambhore *et al.* (2017)**

De Vries and Risco (2005) observed the trends of reproductive performance in the dairy herds of Georgia and Florida and concluded that the average calving interval increased from 399 days in 1976 to 429 days in 2000.

Solemani-Baghshah *et al.* (2014) estimated genetic and phenotypic trends of reproductive traits. Genetic and phonotype trends were analysed by using regression of

average breeding values and phenotype values on calving year. Phonotypic trends of age at first calving and calving interval were estimated to be -3.48 ± 1.08, and -0.41 ± 0.4, respectively. Estimated genetic trends for age at first calving, calving interval were estimated to be 0.07 ± 0.06 and -0.56 ± 0.5, respectively.

Ambhore *et al.* (2017) studied the genetic, phenotypic and environmental trends for first lactation reproduction traits in Phule Triveni population. The genetic trends for reproductive traits under study were found favourable, low and non-significant. A genetic trend of FCI was 0.11 ± 0.07 days BLUP method.

2.2.6 First dry period

The reports on genetic and phenotypic trends are summarised in Table 2.2.6.

Murdia and Tripathi (1991) studied an overall significant decreasing genetic trend for FDP, FCI and AFC and significant decreasing phenotypic trend for TFLY, FCI and AFC in Jersey cattle maintained at Bidaj, Jaipur and Anand for 28 years.

Singh and Nagarcenkar (2000) found genetic phenotypic and environmental trends in FDP and FLMY in five Sahiwal herds (Karnal, Meerut, Durg, Hisar and Chak-Ganjaria) in northern India to assess the selection effectiveness. The phenotypic change rate was negative in larger herds and there was a positive change in small and medium herds for FLMY. It was found that the genetic trend showing show an increase in milk production for Durg, Chak-Ganjaria and Hisar.

Singh and Gurnani (2004) studied phenotypic, genetic and environmental trends for different production and reproduction parameters in Karan Fries and Karan Swiss cattle. In Karan Fries, first lactation length (FLL), first dry period (FDP) and first service period (FSP), the genetic trend was positive and non-significant while the phenotypic trend was insignificant. In Karan Swiss, genetic and phenotypic trends for AFC were significantly negative. The phenotypic trend was negative for FLL, FSP and positive for, FLMY, FL305DMY and FCI, respectively in Karan Swiss cattle.

Chaudhari *et al.* (2014) estimated the phenotypic trend in FDP was 0.88+ 0.36 days/year, which is not in desirable direction. The present study indicates a desirable genetic trend for the trait but influences of non-genetic factors nullified the desirable impact.

Table 2.2.6 Annual genetic and phenotypic trends for first dry period (days)

Breed	Study site	Method	Δ G (Genetic trend)	Δ P (Phenotypic trend)	References
Frieswal	Meerut	Smit I	-7.94 ± 3.71	3.24 ± 0.48	**Mukherjee (2005)**
Frieswal	Meerut	Smit II	-10.49 ± 3.7		**Mukherjee (2005)**
Frieswal	Ambala	Smit I	1.84 ± 4.20	3.08 ± 0.61	**Mukherjee (2005)**
Frieswal	Ambala	Smit II	-3.57 ± 5.11	-	**Mukherjee (2005)**
Sahiwal	Pakistan	BLUP	0.1	2.0	**Rehman *et al*. (2008)**
Sahiwal	Pakistan	BLUP	0.024	-	**Rehman and Khan (2012)**
Crossbred	Hisar	Smith I	-8.58 ± 1.59	0.88 ± 0.36	**Chaudhari *et al.* (2014)**

2.2.7. First service period

The estimates of genetic and phenotypic trends as reported in the literature have been summarized in table 2.2.7.

Rehman *et al.* (2008) in Sahiwal and **Kurien (2011)** in crossbred cattle reported the phenotypic trends as 1.2 and -11.60 ± 3.78 days, respectively. **Mukherjee (2005)** reported a phenotypic trend in Frieswal cattle at Meerut and Ambala farms as 3.37 ± 0.74 and 0.51 ± 0.91 days, respectively while he reported the genetic trends corresponding to the farms estimated by Smith I method as -6.41 ± 5.90 and 4.67 ± 6.19 days. He also found the genetic trend estimates by Smith II method as -13.53 ± 5.91 and -2.83 ± 7.36 days, respectively in Meerut and Ambala farms. **Rehman *et al*. (2008)** estimated the genetic trend as 0.1 days by BLUP method in Sahiwal cattle.

Dash *et al*. (2016) studied the genetic trend in the fertility traits of Holstein Friesian crossbred cattle due to selection favouring production traits. Significant phenotypic trend estimates obtained for FSP 1.14 ± 0.51 days/year.

Ambhore *et al.* (2017) studied the genetic, phenotypic and environmental trends for first lactation reproduction traits in Phule Triveni population. The genetic trends for FSP were found to be negative and statistically non-significant by BLUP methods.

Table 2.2.7 Annual genetic and phenotypic trends for first service period (days)

Breed	Study site	Method	ΔG (Genetic trend)	ΔP (Phenotypic trend)	References
Frieswal	Meerut	Smit I	-6.14 ± 5.90	3.37 ± 0.74	**Mukherjee(2005)**
Frieswal	Meerut	Smit II	-13.53 ± 5.9		**Mukherjee(2005)**
Frieswal	Ambala	Smit I	4.67 ± 6.19	0.51 ± 0.91	**Mukherjee(2005)**
Frieswal	Ambala	Smit II	-2.83 ± 7.36		**Mukherjee(2005)**
Sahiwal	Pakistan	BLUP	1.2	0.1	**Rehman *et al.* (2008)**
Crossbred	-	-	-11.6 ± 3.78	-	**Kurian *et al.* (2011)**
Crossbred	Hisar	Smith I	-8.88 ± 1.69	1.51 ± 0.38	**Chaudhari *et al*. (2014)**
HF	Ludhiana	BLUP	0.02 ± 0.03	1.14 ± 0.51	**Dash *et al*. (2016)**
Phule Triveni	NDRI	BLUP	-0.60 ± 0.38	-0.08 ± 0.13	**Ambhore *et al*. (2017)**

2.2.8 First lactation total milk yield per day of first lactation length (FLMY/FLL)

Narain and Garg (1972) reported positive and non-significant phenotypic and genetic trends for FLMY/FLL in Red Sindhi cattle at Bangalore and Hosur Farms.

Murdia (1991) observed a negative and significant genetic trend for FLMY/FLL in Jersey cattle at Bhiwani Farm.

Nehra (2012) reported a positive genetic and phenotypic trend for FLMY/FLL in KF cattle as 0.08 ± 0.11 and 0.06 ± 0.02 kg per year, respectively.

Chaudhary *et al.* (2014) reported genetic and phenotypic trend for FLMY/FLL in crossbred cattle as 0.41 ± 0.04 and -0.03 ± 0.01 kg per year, respectively.

2.2.9 First lactation total milk yield per day of first calving interval (FLMY/FCI)

Narain and Garg (1972) observed negative and non-significant phenotypic and genetic trends for FLMY/FCI in Red Sindhi cattle at Hosur.

Murdia (1989) reported significantly negative phenotypic and genetic trend for FLMY/FCI in Jersey cattle at Bhiwani, Bidaj and Anand Farms.

Nehra (2012) reported a positive genetic and phenotypic trend for FLMY/FLL in KF cattle as 0.09 ± 0.11 and 0.05 ± 0.04 kg per year, respectively. The phenotypic trend was statistically non-significant.

Chaudhary *et al.* (2014) reported genetic and phenotypic trend for FLMY/FCI in crossbred cattle as 0.45 ± 0.04 and -0.03 ± 0.01 kg per year, respectively.

Materials and Methods

Chapter 3 MATERIALS AND METHODS

3.1 Source of Data

The data on production and reproduction traits in Sahiwal and crossbred cattle were collected from history sheets and milk record registers maintained at Instructional Dairy Farm (IDF), Nagla of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The breeding data used in present study relates to 568 Sahiwal and crossbred cattle sired by 49 sires. The data spread over a period of 30 years (1987-2016). Cows having incomplete and abnormal lactation records due to various reasons were excluded.

3.2 Climate Conditions

The geographical location of Instructional Dairy Farm, Nagla of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar is situated between 28° 52′ to 28° 25′ North latitude and 78° 58′ to 79° 42′ East longitude. The minimum temperature during winter drops down to about 3°C and maximum temperature during summer increases to about 40°C. The annual rainfall is remains between 1300 and 1400 mm, most of the rain fall is received during June to September months. The climate at the farm is subtropical type and the cattle maintained at this farm are exposed to extreme climate conditions.

3.3 Management Practices

Standard management practices are followed at the farm like housing, milking, health coverage, feeding regime, breeding policy and other management practices.

3.3.1 Housing of Animals

The loose and open housing system is practised at the Instructional Dairy Farm, Nagla, Pantnagar. The young ones are reared in calf pens up to 2 weeks and thereafter transferred to open paddock with sheds in the loose housing system. The young ones of different age groups were housed in different paddocks i.e. the animal of age group from two weeks to two month, two months to six months, six months to one year, one year to two year and heifers from two years to conception time. The separate sheds were provided to the dry, lactating and pregnant animals.

3.3.2 Health Coverage

All animals are kept at a high level of sanitary conditions. The IDF has a qualified veterinary officer under whose guidance all animals' health related issues are addressed. The prophylactic vaccination schedule for Foot and Mouth Disease, Hemorrhagic Septicemia and Black Quarter is followed along with the routine deworming programme.

3.3.3 Feeding

The farm has adequate land for growing forage for dairy animals. The balanced rations are given to animals as per NRC nutrient requirement. The young ones are weaned at birth and colostrum is fed to newly born calves for 4 days after which whole milk is allowed for one month age. The roughages, concentrates and mineral blend are given after one month of age to calves. The green fodder and roughages are fed to adult animals in the ratio of 3:1. The concentrate mixture is provided to all animals as per the requirement of their physiological status like youngers, heifers, pregnant, lactation and dry etc.

3.3.4 Breeding Policy

The crossbred cattle maintained at this farm are having exotic inheritance (Holstein Friesian, Jersey and Red Dane as the exotic cattle) less than 50% and more than 50% reaching to the level of 75%. These cows are bred with the semen from sires having 1/2 Holstein Friesian and 1/2 Sahiwal inheritance. The F_1 are inter-se mated to produce F_2 generation. The cows having exotic inheritance level near about 75% are bred using the semen from Sahiwal sire.

3.4 Collection of Data

The following informations were collected on different parameters:

1. First lactation 305 days milk yield
2. First lactation milk yield
3. Date of birth
4. Date of the service
5. Date of calving
6. Date of drying

The first lactation 305 days milk yield was recorded in kg during first lactation and adjusted for 305 days when the milk records were incomplete using the following equation:

$Y = a + b_{yx}$. (305 days actual lactation period)

Y = Predicted 1st lactation 305 days milk yield

a = Observed milk yield of cow

b_{yx} = Regression of y on x

$$b_{yx} = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$$

Where,

y = Actual yield

x = Lactation period

n = No. of paired observation

3.5 Traits Generated

The information on following traits were generated from the collected data:

1. First lactation length (days)
2. Age at first calving (days)
3. First calving interval (days)
4. First dry period (days)
5. First service period (days)
6. First lactation milk yield per day of first lactation length (kg)
7. First lactation milk yield per day of first calving interval (kg)

3.6 Classification of Data

The data were classified and coded based on season and period of birth for age at first calving (AFC) whereas season and period of calving for all other traits as:

3.6.1 Season of Birth\Calving

The year was subdivided into four seasons based on climatological conditions like rainfall, temperature and humidity detailed as under:

S. No.	Name of Season	Group of Months	No. of animals	Code Used
1.	Summer	April to June	142	S1
2.	Rainy	July to September	91	S2
3.	Autumn	October to December	130	S3
4.	Winter	January to March	205	S4
5	Total		568	

3.6.2 Period of Birth/Calving

The data considered for this study were spread over a period of 30 years (1987-2016) for crossbred and Sahiwal cattle. The calves born over a period of 30year have been grouped into 5 groups assuming that the effect of birth year within the groups being similar and that of between the groups being different as there could be variation in the expression of different economic traits over the years due to the effect of changes in feeding and manage mental practices.

Therefore, the entire period was grouped into the following periods.

S. No.	Period of Birth	Period of calving	No. of animal	Code Used
1	1987-1993	1990-1996	93	P1
2	1994-1998	1997-2001	155	P2
3	1999-2003	2002-2006	126	P3
4	2004-2008	2007-2011	101	P4
5	2009-2013	2012-2016	93	P5
6	Total		568	

3.6.3 Age at First Calving

The data on age at first calving were classified into different groups. Sahiwal and crossbred cattle calved at different age have been grouped for groups as below:

S. no.	Age at First calving (days)	Code Used
1	≤1100	A1
2	1101-1300	A2
3	1301-1500	A3
4	≥1500	A4

3.6.4 Genetic group

There are two genetic group Sahiwal and crossbred having 145 and 423 animals, respectively.

3.7 Statistical Analysis

All the statistical analysis was carried out by using "Mixed Model Least Squares and Maximum Likelihood (LSML) Computer Program PC-2" version Harvey (1990).

3.7.1 Effect of Genetic and Non-Genetic Factors

The effect of genetic and non- genetic factors on production and reproduction traits was studied by using "Mixed Model Least Squares and Maximum Likelihood (LSML) Computer Program PC-2" version Harvey (1990).

The effect of genetic and non-genetic factors (period & season of birth) was analyzed using the following mixed model for AFC:

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

Where,

Y_{ijkl} is observation on the lth progeny in k^{th} season j^{th} sire and i^{th} period of birth

μ= Over all mean

P_i = Fixed effect of ith period

S_j= Random effect of jth sire

M_k= Fixed effect of kth season

$e_{ijkl=}$ Random error which is NID (0, σ_e^2)

The effect of genetic and non-genetic factors was analyzed using the following mixed model for other traits.

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

Where,

Y_{ijklm} is observation on the mth progeny in the ith period of jth sire in k^{th} season and l^{th} age group

μ= Overall mean

P_i = Effect of ith period

S_j= Random effect of jth sire

M_k= Effect of kth season

$A_{l=}$ Effect of lth age group

$e_{ijkl=}$ Random error which is NID (0, σ_e^2)

3.7.2 Estimation of Genetic Parameters

The heritability of different production and reproduction traits were estimated by using Model-2 of the "Mixed Model Least Square and Maximum Likelihood (LSML) Computer Program PC-2" version Harvey (1990). For this, the sires were taken as a random effect and other non-genetic factors were taken as fixed effects. The estimation of heritability, genetic correlation and phenotypic correlations was carried out on the first lactation traits as given below:

3.7.2.1 Heritability

The paternal half-sib correlation (Intra-sire correlation among daughters) method used to estimate heritability.

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

Where,

Y_{ij}= Value of jth progeny under ith sire

μ= Overall mean

S_i= Effect of ith sire

e_{ij}= Random error which is NID (0, σ_e^2)

The sire component of variance was estimated as

$$\sigma_s^2 = \frac{MSs - MSe}{K}$$

$$\sigma_e^2 = MS_e$$

Where,

σ_s^2 = Sire component of variance

σ_e^2= Error component of variance

K= Average number of progeny per sire

Intra – class correlation among paternal half- sibs:

$$t = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

$$h^2 = 4t$$

t = Intra – class correlation coefficient

3.7.2.2 Genetic correlation

Genetic correlation was calculated by the following formula:

$$r_{g(xy)} = \frac{\sigma_{s(xy)}}{\sqrt{\sigma_{s(x)}^2 \sigma_{s(y)}^2}}$$

Where,

x and y represents two traits in the same individual,

$\sigma_{s\,(xy)}$ = Sire component of co-variance between traits X and Y

$\sigma^2_{s(x)}$ and $\sigma^2_{s(y)}$ = Sire component of variance due to traits X and Y.

The standard error of genetic correlation (r_g) was estimated by using following formula as:

$$S.E.\ (r_{g)} = \frac{1-\ rg^2}{\sqrt{2}} \frac{\sqrt{S.E.(h_x^2)S.E.(h_y^2)}}{(h_x^2)\ (h_y^2)}$$

Where,

(h^2_x) and (h^2_y) are the heritability estimates of two traits X and Y, respectively.

3.7.2.3 Phenotypic correlation

The phenotypic correlation was estimated by following formula:

$$r_{p(xy)} = \frac{\sigma_{s(xy)} + \sigma_{e(xy)}}{\sqrt{[\sigma^2_{s(x)} + \sigma^2_{e(x)}][\sigma^2_{s(y)} + \sigma^2_{e(y)}]}}$$

Where,

$\sigma_{s(xy)}$= Sire component covariance between traits X and Y

$\sigma_{e(xy)}$= Error component covariance between traits X and Y

$\sigma^2_{s(x)}$ and $\sigma^2_{s(y)}$ = Sire component variance due to traits X and Y

$\sigma^2_{e(x)}$ and $\sigma^2_{e(y)}$ = Error component variance due to traits X and Y

The standard error of the phenotypic correlations was obtained according to the formula given by **Panse and Sukhatme (1967).**

$$SE\ (r_{p(xy)}) = \frac{1-r^2_{p(xy)}}{\sqrt{N-1}}$$

$r_{p\ (XY)}$ = Phenotypic correlation between the traits X and Y

N -1 = Degrees of freedom

N = Total no. of observations

The statistical significance of phenotypic correlation was tested by 't' test as given by **Snedecor and Cochran (1967)** at (N - 1) degrees of freedom.

3.7.3 Genetic and Phenotypic trend

3.7.3.1 Genetic trend

The estimated transmitting ability (ETA) of the sire is half of the additive genetic value and therefore genetic trends was obtained as twice regression of weighted average of sire's transmitting abilities (WAETA) for each year.

$$WAETA = \frac{\Sigma n_{ik}\hat{S}i}{n_k}$$

Where,

n_{ik} = Number of daughter of sire i (i = 1, 2, …..,m) in k^{th} year

$\hat{S}_i$ = Estimated Transmitting Ability (ETA) of ith sire

n_k = Number of daughters of m sires in the kth year

Best Linear Unbiased Prediction estimates of breeding values of individual animals were estimated as:

Y= Xb +Zu + e

Where,

Y = Vector of observations for trait

b = Vector of observations of fixed effects

u = Vector of observations of random effect (Sire)

e = Random error which is NID (0, σ_e^2)

X and Z are the incidence matrices pertaining to fixed and random animal effect respectively.

After predicting the breeding values of animals the trends were estimated by regressing yearly mean of breeding values on birth year.

3.7.3.2 Phenotypic trend

The phenotypic trend for each trait was calculated by taking regression of performance of the population on the year as $b_{P.T.}$

$$\Delta P = b_{P.T} = \frac{\sum Pt}{\sum t^2}$$

$$S.E.\ (\Delta P) = \sqrt{\frac{\sum P^2 - b_{P.T.}(\sum Pt)}{(\sum t^2)\ (N-2)}}$$

Where,

$b_{P.T}$ = Linear regression of population performance (P) on time (year) of calving (T),

ΣPt = Corrected sum of products for trait (P) and time (T),

Σt^2 = Corrected sum of squares for time taken as a deviation from its mean.

ΣP^2 = Corrected sum of squares of traits

N = Total number of records

3.7.3.3 Environmental Trends

Environmental trend (ΔE) was obtained by subtracting the genetic trend (ΔG) from the overall phenotype trend (ΔP).

$$\Delta E = \Delta P - \Delta G$$

The standard error of environmental trend, S.E. (ΔE) was calculated as:

$$SE(\Delta E) = \sqrt[2]{SE(\Delta P)^2 + SE(\Delta G)^2}$$

Results and Discussion

Chapter 4 RESULTS AND DISCUSSION

The present study was conducted to estimate averages of various first lactation production and reproduction traits, to study the effect of genetic and non-genetic factors, to estimate genetic parameters and to estimate genetic and phenotypic trends of first lactation production and reproduction traits in Sahiwal and crossbred cattle. Therefore, the results of the present study have been presented and discussed under the following headings:

4.1 Averages of first lactation production and reproduction traits

4.2 Heritability of first lactation production and reproduction traits

4.3 Genetic and phenotypic correlations among first lactation traits

4.4 Genetic and phenotypic trends of production and reproduction traits

4.1 Averages of first lactation production and reproduction traits.

The least squares mean and least squares analysis for first lactation traits have been summarized in table 4.1 and 4.2, respectively.

4.1.1 First Lactation 305 Days Milk Yield (FL305 DMY)

The overall least squares mean for FL305DMY was observed as 2231.29 ± 65.27 kg (Table 4.1). The result of the present study was similar to the results reported by **Parveen *et al.* (2018), Raja (2004), Mandal and Sachdeva (2001)** and **Rao *et al.* (2000)**. However, higher values of FL305DMY than the present study have been observed by **Dash *et al.* (2016), Nehra *et al.* (2012)** and **Singh and Gurnani (2004),** while lower values than the present study were reported by **Rehman *et al.* (2008)** and **Chawla *et al.* (2017)**.

4.1.1.1 Effect of genetic group on FL305DMY

The effect of genetic group on FL305DMY was found highly significant ($P \leq 0.01$) in Sahiwal and crossbred (Table 4.2). The least squares mean were found as 1857.72 ± 148.38 kg for Sahiwal cattle and 2604.85 ± 142.69 kg for crossbred cattle (Table 4.1).

Table 4.1 Least-squares means with standard error for first lactation production and reproduction traits in Sahiwal and crossbred cattle

S. N.	Source	No. of Observations	LSM ±SE								
			FL305DMY	FLMY	FLL	AFC	FCI	FDP	FSP	FLMY/ FLL	FLMY/ FCI
	Overall Mean	568	2231.29 ± 65.27	2453.39 ± 84.33	317.33 ± 4.15	1303.8 ± 21.06	457.14 ± 8.76	137.66 ± 6.47	184.3 ± 8.24	7.59 ± 0.21	5.51 ± 0.19
Genetic Group											
1	Crossbred	423	2604.85 ± 142.69	2963.24 ± 207.29	344.08 ± 12.54	1268.58 ± 52.68	474.15 ± 23.61	130.84 ± 16.46	191.28 ± 23.24	8.58 ± 0.49	6.38 ± 0.43
2	Sahiwal	145	1857.72 ± 148.38	1943.55 ± 216.01	290.57 ± 13.11	1339.02 ± 54.72	440.12 ± 24.64	144.48 ± 17.16	177.33 ± 24.26	6.59 ± 0.51	4.64 ± 0.44
Periods											
1	P1 (1990-1996)	93	2281.66 ± 169.18	2634.4 ± 247.73	329.95 ± 15.14	1347.88 ± 63	462.18 ± 28.36	138.81 ± 19.71	191.63 ± 27.97	7.95 ± 0.59	5.71 ± 0.51
2	P2 (1997-2001)	155	2478.41 ± 120.37	2792.55 ± 172.88	351.94 ± 10.31	1342.35 ± 43.79	479.63 ± 19.55	132.86 ± 13.69	203.78 ± 19.18	7.85 ± 0.41	5.79 ± 0.36
3	P3 (2002-2006	126	2259.46 ± 118.87	2418.47 ± 170.56	315.28 ± 10.16	1230.99 ± 42.95	460.48 ± 19.27	145.1 ± 13.5	188.27 ± 18.9	7.58 ± 0.41	5.37 ± 0.35
4	P4 (2007-2012)	101	2027.04 ± 150.54	2174.18 ± 219.3	304.85 ± 13.32	1260.2 ± 55.31	433.91 ± 25.03	134.21 ± 17.42	167.45 ± 24.65	6.88 ± 0.52	5.32 ± 0.45
5	P5 (2013-2016)	93	2109.86 ± 209.12	2247.38 ± 308.25	284.61 ± 18.99	1337.56 ± 78	449.47 ± 35.44	137.31 ± 24.56	170.39 ± 35	7.66 ± 0.73	5.37 ± 0.63

Table 4.1 Contd…

S. N.	Source	No. of Observations	LSM ±SE								
			FL305DMY	FLMY	FLL	AFC	FCI	FDP	FSP	FLMY/ FLL	FLMY/ FCI
Seasons											
1	S1 (April-June)	142	2265.24 ± 78.14	2490.28 ± 105.92	320.95 ± 5.77	1327.08 ± 26.69	463.7 ± 11.48	144.17 ± 8.25	190.94 ± 11.05	7.67 ± 0.26	5.55 ± 0.23
2	S2 (July-September)	91	2164.18 ± 86.56	2333.78 ± 119.62	315.94 ± 6.74	1264.05 ± 30.08	440.99 ± 13.16	132.95 ± 9.37	163.99 ± 12.75	7.23 ± 0.29	5.43 ± 0.26
3	S3 (Oct-December)	130	2273.66 ± 80.97	2522.4 ± 110.56	317.26 ± 6.1	1320.66 ± 27.82	463.82 ± 12.05	137.7 ± 8.63	192.54 ± 11.63	7.8 ± 0.27	5.6 ± 0.24
4	S4(January-March)	205	2222.06 ± 72.73	2467.13 ± 96.96	315.14 ± 5.12	1303.41 ± 24.37	460.04 ± 10.36	135.8 ± 7.52	189.75 ± 9.9	7.63 ± 0.23	5.46 ± 0.21
AFC Group											
1	A1(≤1100)	161	2092.36 ± 77.2	2227.97 ± 104.39	311.46 ± 5.66	-	445.25 ± 11.29	138.11 ± 8.13	175.01 ± 10.85	7.07 ± 0.25	5.19 ± 0.23
2	A2(1101-1300)	196	2291.47 ± 73.97	2504.19 ± 99.04	318.65 ± 5.27	-	457.44 ± 10.62	133.78 ± 7.69	186.03 ± 10.17	7.69 ± 0.24	5.65 ± 0.22
3	A3(1301-1500)	120	2320.01 ± 80.84	2603.02 ± 110.35	320.33 ± 6.09	-	460.49 ± 12.03	127.96 ± 8.62	184.08 ± 11.6	7.97 ± 0.27	5.79 ± 0.24
4	A4(≥1500)	91	2221.31 ± 90.23	2478.41 ± 125.52	318.87 ± 7.14	-	465.36 ± 13.88	150.78 ± 9.85	192.1 ± 13.48	7.62 ± 0.3	5.41 ± 0.27

Table 4.2 Analysis of variance for the factors affecting first lactation production and reproduction traits in Sahiwal and crossbred cattle

Source of Variation	d.f.	Mean Squares (MS Values)							
		FL305DMY	FLMY	FLL	FCI	FDP	FSP	FLMY/ FLL	FLMY/ FCI
SIRE	48	800168.3**	1441450**	4113.19*	16643.19**	8688.73**	15282.5**	8.08**	6.62**
GENETIC GROUP	1	2637220**	4912301**	13530.3*	5473.88	879.02	919.37	18.67**	14.34*
PERIOD	4	560170.8	1110512	11363.25**	5141.36	1249.42	3173.63	2.29	1.08
SEASON	3	237778.9	613412.3	892.86	10592.80	2552.87	16567.19	5.41	0.69
AFC GROUP	3	1302941**	3004670**	1840.15	7168.90	8392.06	4874.10	16.60*	8.52*
ERROR	508	319907.3	712478.6	2783.20	9553.64	4547.49	9376.20	3.91	2.84

** Significant at $P \leq 0.01$ * Significant at $P \leq 0.05$

Sire had highly significant (P≤ 0.01) effect on FL305DMY. Significant effect was also reported by **Parveen *et al.* (2018)**, **Singh and Gurnani (2004)**, **Mukherjee (2005)** and **Dash *et al.* (2016)**.

4.1.1.2 Effect of period of calving on FL305DMY

The period of calving had a non-significant effect on FL305DMY (Table 4.2). The least squares means for FL305DMY varied from 2027.04 ± 150.54 for Period-4 to 2478.41 ± 120.37 for Period-2 (Table 4.1).

The non-significant effect of period on FL305DMY was also reported by **Rao *et al.* (2000)**, **Singh and Gurnani (2004)** and **Nehra *et al.* (2012)** in crossbred cattle, while significant effect of period was also reported by **Parveen *et al.* (2018)** in Sahiwal cattle and **Singh *et al.* (2006)**, **Dash *et al.* (2016)** in Karan Fries.

4.1.1.3 Effect of season of calving on FL305DMY

The season of calving had a non-significant effect on FL305DMY (Table 4.2). The least squares means for FL305DMY varied from 2164.18 ± 86.56 for rainy season calvers to 2273.66 ± 80.97 for autumn season calvers (Table 4.1).

The non-significant effect of season on FL305DMY was also reported by **Raja (2004)** in Sahiwal, **Singh *et al.* (2006)**, **Rashia (2010)** and **Nehra *et al.* (2012)** in Karan Fries. However, the significant effect was reported by **Parveen *et al.* (2018)** in Sahiwal cattle, **Mukherjee (2005)** in Frieswal, and **Dash *et al.* (2016)** in Karan Fries.

4.1.1.4 Effect of age at first calving (AFC) groups on FL305DMY

The AFC groups had a highly significant (P≤ 0.01) effect on FL305DMY (Table 4.2). Significant effect of AFC groups was also reported by **Parveen *et al.* (2018)** in Sahiwal, **Mukherjee (2005)** in Frieswal and **Nehra *et al.* (2012)** in Karan Fries cattle, while non-significant effect was reported by **Rao *et al.* (2000)** in crossbred, **Panja (1997)** and **Singh (1995)** in Karan Swiss.

4.1.2 First Lactation Milk Yield (FLMY)

The overall least squares mean for FLMY was found to be 2453.39 ± 84.33 kg (Table 4.1). The results of the present study were similar to those reported by **Parveen *et al.,* (2018), Sing *et al.* (2005), Reddy (1983)** and **Akhtar *et al.* (2003).**

However, the higher value of FLMY than the present study observed by **Mukherjee (2005), Sahana and Gurnani (2000), Sinha (1999), Sivakumar (1998), Panja (1997) and Singh (1995)**.

4.1.2.1 Effect of genetic group on FLMY

The effect of genetic group on FLMY was found highly significant (P≤0.01) (Table 4.4). The least squares mean was found 1943.55 ± 216.01 kg for Sahiwal cattle and 2963.24 ± 207.29 kg for crossbred cattle (Table 4.1).

Sire had highly significant (P≤ 0.01) effect on FLMY. Significant effect was also reported by **Parveen *et al.* (2018), Sing and Singh (2016)** in Sahiwal cattle, **Mukherjee (2005)** in Frieswal cattle and **Nehra *et al.* (2012)** in Karan Fries. However, **Bhattacharya *et al.* (2002), Saha (2001), Dutt and Kumar (2000)** observed the non-significant effect.

4.1.2.2 Effect of period of calving on FLMY

Period of calving had a non-significant effect on FLMY (Table 4.2). The least-squares mean for FLMY varied from 2174.18 ± 219.30 kg for Period-4 to 2792.55 ± 172.88 kg for Period-2 (Table 4.1).

Significant effect was reported by **Sing and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle, while the non-significant effect was reported by **Sahana and Gurnani (2000)** and **Saha (2001)** in Karan Fries.

4.1.2.3 Effect of season of calving on FLMY

Season of calving had a non-significant effect on FLMY was (Table 4.2). The least squares means for FLMY varied from 2333.78 ± 119.63 kg for rainy season calvers to 2522.40 ± 110.56 kg for autumn season calvers (Table 4.2).

The non-significant effect of season on FLMY was also reported by **Sing and Singh (2016)** in Sahiwal**, Bhattacharya *et al.* (2002)** in Holstein Friesian crosses, **Saha (2001)** in Karan Fries while significant effect was reported by **Dash *et al.* (2016)** in Karan Fries and **Parveen *et al.* (2018)** in Sahiwal cattle.

4.1.2.4 Effect of age at first calving (AFC) groups on FLMY

AFC groups had highly significant (P≤ 0.01) effect on FLMY (Table 4.2). Significant effect of age at first calving was also reported by **Saha (2001)** and **Sahana**

and Gurnani (2000) in Karan Fries, while the non-significant effect was reported by **Panja (1997)** in Karan Fries, **Singh (1995)** in Karan Swiss and **Mukherjee (2005)** in Frieswal cattle.

4.1.3 First Lactation Length (FLL)

The overall least squares mean for FLL was found 317.33 ± 4.15 days (Table 4.1). The estimates were quite similar to those reported by **Parveen *et al.* (2018)** and **Singh and Singh (2016)** in Sahiwal cattle and **Mukherjee (2005), Akhtar *et al.* (2003), Bhattacharya *et al*. (2002)** and **Saha (2001)** in crossbred. The higher value of FLL than the present study was observed by **Singh (1995)**, **Panja (1997)**, **Sinha (1999)**, **Sahana and Gurnani (2000)** and **Nehra (2012)**, while lower values than the present study were reported by **Kannan (2002), Raja (2004)**, **Javed *et al.* (2000) and Mandal and Sachdeva (2001).**

4.1.3.1 Effect of genetic group on FLL

It was found that genetic group had a significant (P≤0.05) effect on FLL (Table 4.2). The least-squares mean for FLL was found as 290.5 ± 13.11 days for Sahiwal cattle and 344.08 ± 12.54 days for crossbred cattle (Table 4.1).

Sire had a significant (P≤ 0.05) effect on FLL. Significant effect was also observed by **Parveen *et al.,* (2018)** and **Singh and Singh (2016)** in Sahiwal and **Nehra (2012)** and **Dash *et al.* (2016)** in Karan Fries, while non-significant effect was reported by **Saha (2001)** in Karan Fries **Bhattacharya *et al*. (2002)** in Holstein Friesian cross **Mandal and Sachdeva (2001)** in Karan Swiss and **Mukherjee (2005)** in Frieswal.

4.1.3.2 Effect of period of calving on FLL

Period of calving had highly significant (P≤ 0.01) effect on FLL (Table 4.2). The least-squares mean for FLL varied from 284.61 ± 18.99 for Period-5 to 351.28 ± 10.31 for Period-2 (Table 4.1).

Significant effect of period on FLL was also reported by **Parveen *et al*. (2018)** in Sahiwal, **Saha (2001)** in Karan Swiss cattle, **Nehra (2012)** and **Dash *et al.* (2016)** in Karan Fries and cattle. However, the non-significant effect was reported by **Panja (1997)** and **Saha (2001)** in Karan Fries and **Mukherjee (2005)** in Frieswal cattle.

4.1.3.3 Effect of season of calving on FLL in crossbred and Sahiwal cattle

The effect of season of calving on FLL was found non-significant (Table 4.2). The least squares mean for FLL varied from 315.14 ± 5.12 days for rainy season calvers to 320.95 ± 5.77 days for summer season calvers (Table 4.1).

The non-significant effect of season on FLL was also reported by **Raja (2004)** in Sahiwal, **Nehra *et al.* (2012)** in Karan Fries and **Sing and Singh (2016**) in Sahiwal cattle, while significant effect was reported by **Parveen *et al.* (2018)** in Sahiwal, **Dash *et al.* (2016)** in Karan Fries, **Mukherjee (2005)** in Frieswal cattle and **Mandal and Sachdeva (2001)** in Karan Swiss.

4.1.3.4 Effect of age at first calving (AFC) groups on FLL

AFC groups had a non-significant effect on FLL (Table 4.2). The non-significant effect of AFC groups on FLL was also reported by **Gupta *et al.* (1986)**, **Kumar (1987)** and **Singh (1995)** in Karan Swiss cattle and **Sinha (1999)** and **Nehra *et al.* (2012)** in Karan Fries cattle, while significant effect was observed by **Parveen *et al.* (2018)** in Sahiwal, **Mukherjee (2005)** in Frieswal and **Saha (2001)** in Karan Swiss cattle.

4.1.4 Age at First Calving (AFC)

The overall least squares mean for AFC was found as 1303.80 ± 21.06 days (Table 4.1). The result of the present finding is in close agreement with the findings of **Singh and Singh (2016)** in Sahiwal cattle and **Dubey and Singh (2005)** in crossbred. However, lower values than the present findings were observed by **Raja (2004), Parveen *et al.* (2018)** in Sahiwal, **Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle. Higher value than the present study was reported by **Kuralkar *et al.* (1996)** in Sahiwal cattle.

4.1.4.1 Effect of genetic group on AFC

It was found that genetic group had a statistically non-significant effect on AFC (Table 4.2a). The least squares mean was found as 1339.02 ± 54.72 in Sahiwal cattle and 1268.58 ± 52.68 in crossbred cattle (Table4.1).

Sire had a highly significant ($P \leq 0.01$) effect on AFC. The significant effect was also reported by **Singh and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle,

Mukherjee (2005) in Frieswal and **Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle.

However, the non-significant effect was observed by **Singh and Dubey (2005)** in crossbred and Sahiwal cattle.

4.1.4.2 Effect of period of birth on AFC

The period of birth had a non-significant effect on AFC (Table 4.2a). The least squares mean for AFC varied from 1230.99 ± 42.95 days for Period-3 to 1347.88 ± 63 for Period-1 (Table 4.1)

The significant effect of the period of birth on AFC was reported by, **Singh and Singh (2016)** and **Parveen *et al.* (2018)** in Sahiwal cattle and **Mukherjee (2005)** in Frieswal. However, the non-significant effect was reported by **Raja (2004)** in Sahiwal and **Saha (2001), Sahana and Gurnani (2000)** and **Nehra *et al.* (2012)** in Karan Fries cattle.

Table 4.2(a) Analysis of variance for the factors affecting AFC in Sahiwal and crossbred cattle

Source of variation	d.f.	Sum of square	Mean squares
SIRE	48	4741242	98775.88**
GENETIC GROUP	1	23542.95	23542.95
PERIOD	4	334755.4	83688.84
SEASON	3	222649.4	74216.48
ERROR	511	23671895	46324.65

** Significant at P≤0.01 * Significant at P≤0.05

4.1.4.3 Effect of season of birth on AFC

The season of birth had a non-significant effect on AFC (Table 4.2a). The least squares mean varied from 1264.05 ± 30.08 days for rainy season calvers to 1327.08 ± 26.69 days for summer season calvers (Table 4.1).

The non-significant effect of season on AFC was also reported by **Singh and Singh (2016)** in Sahiwal cattle, **Sinha (1999)** and **Nehra *et al.* (2012)** in Karan Fries cattle and **Mukherjee (2005)** in Frieswal, while significant effect was reported by **Parveen *et al.* (2018)** and **Rehman *et al.* (2008)** in Sahiwal, and **Akhtar *et al*. (2003)** and **Panja (1997)** in crossbred cattle.

4.1.5 First Calving Interval (FCI)

The overall least-squares means of FCI was found 457.14 ± 8.76 days (Table 4.1). The estimates were quite similar to those reported by **Raja (2004), Banik (2004)**, **Singh (1992)** in Sahiwal, **Kumar *et al.* (1991)** and **Raheja *et al.* (1994)** in Holstein Friesian cross, and **Chaudhary *et al.* (1995)** in Jersey x Sahiwal cross. However, lower values than the present findings were reported by **Parveen *et al*. (2018)** in Sahiwal and **Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle. Higher value than the present study was observed by **Yadav *et al.* (2004)** in crossbred cattle.

4.1.5.1 Effect of genetic group on FCI

It was found that genetic group had a statistically non-significant effect on FCI (Table 4.2). The least squares mean was found 440.12 ± 24.64 days for Sahiwal cattle and 474.15 ± 23.16 days for crossbred cattle (Table 4.1).

Sire had highly significant ($P \leq 0.01$) effect on FCI. The significant effect was reported by **Parveen *et al*. (2018)** in Sahiwal and **Hammoud *et al.* (2010)** in Holstein Friesian crossbred cattle. However, the non-significant effect was reported by **Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle, **Raja (2004)** in Sahiwal and **Mukherjee (2005)** in Frieswal.

4.1.5.2 Effect of period of calving on FCI

The effect of the period of calving on FCI was found non-significant (Table 4.2). The least squares means for FCI varied from 433.91 ± 25.03 for Period-4 to 479.63 ± 19.55 for Period-2 (Table 4.1).

The significant effect of period on FCI was also reported by **Mukherjee (2005)** in Frieswal, **Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle and **Raja (2004)** and **Parveen *et al*. (2018)** in Sahiwal. However, the non-significant effect was reported by **Saha (2001)** in Karan Fries and **Akhtar *et al.* (2003)** in Holstein Friesian crosses.

4.1.5.3 Effect of season of calving on FCI

The Season of calving had a non-significant effect on FCI (Table 4.2). The least squares means for FCI varied from 440.99 ± 13.16 for rainy season calvers to 463.82 ± 12.05 for autumn season calvers (Table 4.1).

The non-significant effect of season on FCI was also reported by **Singh and Singh (2016)** and **Raja (2004)** in Sahiwal, **Singh (1995)** and **Saha (2001)** in Karan Swiss cattle and **Nehra *et al.* (2012)** in Karan Fries cattle**,** while significant effect was reported by **Parveen *et al.* (2018)** in Sahiwal, **Hammoud *et al.* (2010)** in Holstein Friesian cross and **Mukherjee (2005)** in Frieswal cattle.

4.1.5.4 Effect of age at first calving (AFC) groups on FCI

The AFC groups had a non-significant effect on FCI (Table 4.2). The non-significant effect of AFC groups on FCI was also reported by **Parveen *et al*. (2018)** in Sahiwal and **Singh (1995), Panja (1997), Saha (2001)** and **Nehra *et al.* (2012)** in Karan Fries cattle.

4.1.6 First Dry Period (FDP)

The overall least squares means of FDP was observed as 137.66 ± 6.47 days (Table 4.1). The estimate was quite similar to those reported by **Raja (2004)** and **Chawla and Mishra (1982)** in Sahiwal cattle, **Mukherjee (2005)** in Frieswal and **Nayak and Raheja (1996)** in Holstein Friesian cross. However, lower values than the present study were reported by **Singh and Gurnani (2004), Akhtar *et al.* (2003), Saha (2001) and Panja (1997)** in crossbred cattle.

4.1.6.1 Effect of genetic group on FDP

It was found that genetic group had a statistically non-significant effect on FDP (Table 4.2). The least squares mean was found to be 144.48 ± 17.16 days for Sahiwal cattle and 130.84 ± 16.48 days for crossbred cattle.

Sire had highly significant ($P \leq 0.01$) effect on FDP. The significant effect was also reported by **Saha (2001)** in Karan Fries cattle and **Akhtar *et al.* (2003)** in Holstein Friesian cross. However, the non-significant was reported by **Singh (1995)** and **Panja (1997)** in Karan Fries cattle and **Mukherjee (2005)** in Frieswal.

4.1.6.2 Effect of period of calving on FDP

The period of calving had a non-significant effect on FDP (Table 4.2). The least squares mean for FDP varied from 132.86 ± 13.69 days for Period-2 to 145.10 ± 13.50 days for Period-3 (Table 4.1).

The non-significant effect of period on FDP was also reported by **Chawla and Mishra (1982)** in Sahiwal cattle and **Sahana and Gurnani (2000), Saha (2001)** and **Saha *et al.* (2010)** in Karan Fries cattle. However, **Akhtar *et al.* (2003)** in Holstein Friesian crosses and **Raja (2004)** in Sahiwal found significant effect.

4.1.6.3 Effect of season of calving on FDP

The season of calving had a non-significant effect on FDP (Table 4.2). The least-squares mean for FDP varied from 132.9 ± 9.37 days for rainy season calvers to 144.17 ± 8.25 days for summer season calvers (Table 4.1).

The non-significant effect of season on FCI was also reported by **Sahana and Gurnani (2000), Saha (2001)** and **Singh and Gurnani (2004)** in Karan Fries cattle and **Rehman *et al.* (2006)** and **Zafar *et al.* (2008)** in Sahiwal cattle.

4.1.6.4 Effect of age at first calving (AFC) groups on FDP

The AFC group had a non-significant effect on FDP (Table 4.2). The non-significant effect of AFC groups on FDP was also reported by **Panja (1997), Sahana and Gurnani (2000)** and **Saha (2001)** in Karan Fries cattle. However, the significant effect was reported by **Mukherjee (2005).**

4.1.7 First Service Period (FSP)

The overall least-squares means of FSP was found as 184.30 ± 8.24 days (Table 4.1). The estimate was quite similar to those reported by **Rehman *et al.* (2008)** in Sahiwal**, Bhatia and Pandey (1990)** in Holstein Friesian crosses and **Arora *et al.* (1993)** and **Mukherjee (2005)** in Frieswal. However, lower estimates than present study were reported by **Divya (2012), Raja (2004), Saha (2001)** and **Panja (1997),** while that of higher value **Banik (2004)** and **Kathiravan *et al.* (2009)** in Sahiwal cattle.

4.1.7.1 Effect of genetic group on FSP

It was found that genetic group had the statistically non-significant effect on FSP (Table 4.2). The least squares mean was found 177.33 ± 24.26 days for Sahiwal cattle and 191.28 ± 23.24 days for crossbred cattle (Table 4.1).

Sire had highly significant (P≤ 0.01) effect on FSP. However, the non-significant effect was reported by **Mukherjee (2005), Panja (1997), Saha (2001)** and **Singh (1995)**.

4.1.7.2 Effect of period of calving on FSP

The effect of the period of calving on FSP was found non-significant (Table 4.2). The least squares means for FSP varied from 167.45 ± 24.65 for Period-4 to 203.78 ± 19.18 for Period-2 (Table 4.1).

The non-significant effect of period on FSP was also reported by **Bhatia and Pandey (1990)** in Holstein Friesian cross, **Singh (1995)** and **Saha (2001)** in Karan Fries cattle and **Kathiravan *et al.* (2009)** in Sahiwal. However, the significant effect was reported by **Rehman *et al.* (2008)** and **Raja (2004)** in Sahiwal and **Divya (2012), Saha (2001)** and **Panja (1997)** in Karan Fries cattle.

4.1.7.3 Effect of season of calving on FSP

The effect of season of calving on FSP was found non-significant (Table 4.2). The least squares mean for FSP varied from 163.99 ± 12.75 days for rainy season calvers to 192.54 ± 11.63 days autumn season calvers (Table 4.1).

The non-significant effect of season on FSP was also reported by **Raja (2004)** and **Kathiravan *et al.* (2009)** in Sahiwal cattle and **Singh (1995)** and **Divya (2012)** in Karan Fries cattle. However, **Mukherjee (2005)** and **Saha (2001)** found significant effect.

4.1.7.4 Effect of age at first calving (AFC) groups on FSP

The AFC groups had a non-significant effect on FSP (Table 4.2). The non-significant effect of AFC groups on FSP was also reported by **Singh and Singh (2016)** in Sahiwal, **Panja (1997), Singh (1995)** and **Divya (2012)** in Karan Fries cattle, while **Sahana (1996)** and **Mukherjee (2005)** found significant effect.

4.1.8 First Lactation Milk Yield/First Lactation Length (FLMY/FLL)

The overall least squares mean of FLMY/FLL was found 7.59 ± 0.21 kg (Table 4.1). This was quite similar to the results reported by Nehra (2012) and Dash (2014).

4.1.8.1 Effect of genetic group on FLMY/FLL

The effect of genetic group was found highly significant (P≤0.01) (Table 4.2). The least squares mean was observed as 6.59 ± 0.51 kg for Sahiwal cattle and 8.58 ± 0.49 kg for crossbred cattle (Table 4.1)

The effect of sire on FLMY/FLL was found highly significant (P≤ 0.01). The significant effect was also observed by **Nehra (2012)** and **Singh *et al.* (1993)** in crossbred cattle.

4.1.8.2 Effect of period of calving on FLMY/FLL

The effect of the period of calving on FLMY/FLL was found non-significant (Table 4.2). The least squares means for FLMY/FLL varied from 6.88 ± 0.52 kg for Period-4 to 7.95 ± 0.59 kg for Period-1 (Table 4.1).However, significant effect of the period was reported by **Nehra (2012), Dash (2014)** and **Singh *et al.* (1993)**.

4.1.8.3 Effect of season of calving on FLMY/FLL

The effect of season was found non-significant (Table 4.2). The least-square mean for FLMY/FLL varied from 7.23 ± 0.29 kg for rainy season calvers to 7.8 ± 0.27 for autumn season calvers (Table 4.1). The non-significant effect of the period was also reported by **Nehra (2012).** However, the significant effect was reported by **Dash (2014).**

4.1.8.4 Effect of AFC groups on FLMY/FLL

The effect of the AFC groups was found significant (Table 4.2). **Nehra (2012)** and **Dash (2014)** also found the significant effect of AFC groups on FLMY/FLL.

4.1.9 First Lactation Milk Yield/First Calving Interval (FLMY/FCI)

The overall least-squares mean of FLMY/FCI was found 5.51 ± 0.19 kg (Table 4.1). The estimates were quite similar to the result reported by **Nehra (2012)**. However, **Dash (2014)** found a higher value than the present study.

4.1.9.1 Effect of genetic group on FLMY/FCI

The effect of genetic group was found significant (P≤0.05) (Table 4.2)**.** The least squares mean was found 4.64 ± 0.44 kg for Sahiwal cattle and 6.38 ± 0.43 kg for crossbred cattle (Table 4.1).

The effect of sire on FLMY/FCI was found highly significant (P≤ 0.01). **Nehra (2012)** also found the significant effect.

4.1.9.2 Effect of period of calving on FLMY/FCI

Period of calving had non-significant effect on FLMY/FCI (Table 4.2). The least-square mean for FLMY/FLL varied from 5.32 ± 0.45 kg for Period-4 to 5.79 ± 0.36 kg for Period-2 (Table 4.1). The significant effect of the period was also reported by **Nehra (2012), Dash (2014)** and **Singh *et al.* (1993)**.

4.1.9.3 Effect of season of calving on FLMY/FCI

The effect of season was found non-significant on FLMY/FCI (Table 4.2). The least squares mean for FLMY/FCI varied 5.43 ± 0.26 kg for rainy season calvers to5.60 ± 0.24 kg for autumn season calvers (Table 4.1). The non-significant effect of the period was also reported by **Nehra (2012)** and **Dash (2014).**

4.1.9.4 Effect of AFC groups on FLMY/FCI

The effect of the AFC groups was found significant (Table 4.2). **Nehra (2012)** also found significant effect of AFC groups on FLMY/FLL, while **Dash (2014)** found non-significant effect of AFC groups.

4.2 Heritability of First Lactation Production and Reproduction Traits

The heritability of a trait gives an idea of the proportion of genetic variance with respect to the total phenotypic variance in a given population for a particular trait over a given period of time. It also measures the regression of the additive genetic value of an animal in phenotype. Knowledge of this parameter is essential in the formulation of appropriate evaluation and selection criteria to achieve genetic improvement. Therefore, it is necessary to determine the heritability of various traits under consideration. The heritability estimates along with standard error for various first lactation traits were estimated by paternal half-sib correlation method. The heritability estimated for various first lactation traits has been summarized into table 4.3.

4.2.1 First Lactation 305 Days Milk Yield (FL305DMY)

The heritability of FL305DMY was observed as 0.41 ± 0.13 (Table 4.3). Similar estimates were reported by **Dash *et al.* (2016), Nehra (2012), Singh *et al.* (2006)** and **Singh (1995),** while higher values than the present study was reported by **Raja (2004)** in Sahiwal cattle and **Dutt and Joshi (1992)** in crossbred cattle. However, comparatively lower value was reported by **Parveen *et al.,* (2018**) and **Rehman *et al.,* (2008)** in Sahiwal and **Rashia (2010), Mukherjee (2005), Saha (2001),** and **Panja (1997)** 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.

Table 4.3 Heritability estimates of first lactation production and reproduction traits in Sahiwal and crossbred cattle

Traits	h^2 ± S.E.
	Sahiwal and crossbred
FL305DMY	0.41 ± 0.13
FLMY	0.30 ± 0.11
FLL	0.15 ± 0.09
AFC	0.33 ± 0.12
FCI	0.23 ± 0.10
FDP	0.27 ± 0.11
FSP	0.19 ± 0.10
FLMY/FLL	0.31 ± 0.11
FLMY/FCI	0.38 ± 0.12

4.2.2 First Lactation Milk Yield (FLMY)

The heritability of FLMY was estimated as 0.30 ± 0.11 (Table 4.3). Similar estimates were observed by **Saha (2001), Sahana and Gurnani (2000)** and **Singh (1995)**. However, comparatively higher values of heritability were reported by

Singh *et al.* (2005) and **Raja (2004)** in Sahiwal cattle and **Pyne *et al.* (1988)** and **Jadhav *et al*. (1991)** in crossbred cattle**,** while lower value was estimated by **Parveen *et al.* (2018)** and **Singh (1992)** in Sahiwal and **Mukherjee (2005), Raheja *et al*. (1994)** and **Tajane and Rai (1989)** in crossbred cattle. A moderate value of the heritability of this trait suggested that there is the scope of improvement by selection with proper management practices.

4.2.3 First Lactation length (FLL)

The heritability estimate of FLL was found to be 0.15 ± 0.09 (Table 4.3). Almost similar estimates were reported by **Parveen *et al.* (2018)** and **Kannan (2002)** in Sahiwal and **Nehra (2012)**, **Saha (2001), Sahana and Gurnani (2000), Mukherjee (2005)** and **Singh (1995)** in crossbred cattle. However, the lower value than the present study was reported by **Singh *et al*. (2005)**, **Banik (2004)** and **Javed *et al.* (2000)** in Sahiwal and **Dash *et al.* (2016), Singh (1995), Singh *et al.* (1993)** and **Jadhav *et al.* (1991)** in crossbred cattle, while comparatively higher value was observed by **Raja (2004)** and **Kumar (2003)** in Sahiwal and **Gupta *et al.* (1986)** in crossbred cattle.

4.2.4 Age at First Calving (AFC)

The heritability estimate of AFC was found to be 0.33 ± 0.12 (Table 4.1). Similar findings were reported by **Raja (2004)** and **Dubey and Singh (2005)** in Sahiwal and **Mukherjee (2005), Saha (2001)** and **Kumar (1986)** in crossbred cattle. Higher estimates of heritability of this trait were reported by **Parveen *et al.,* (2018)** and **Singh and Singh (2016)** in Sahiwal and **Nehra (2012), Panja (1997)** and **Singh (1995)** in crossbred cattle, while lower estimates were reported by **Manoj (2009), Rehman *et al.* (2008)** and **Reddy (1983)** in Sahiwal and **PDC AR (2003-04) and Arora *et al.* (1993)** in crossbred cattle. The moderate value of heritability for this trait suggested that improvement could be possible in this trait by better management practices.

4.2.5 First Calving Interval (FCI)

The heritability estimate of FCI was found to be 0.23 ± 0.10 in Sahiwal and crossbred cattle. The estimates of heritability similar to the present study were reported by **Parveen *et al.* (2018)** and **Raja (2004)** in Sahiwal and **Nehra (2012)** in crossbred cattle. The higher value than the present study was reported by and **Singh (1992)** in Sahiwal and **Saha (2001)** in crossbred cattle, while lower value than the present study

was reported by **Singh and Singh (2016), Banik (2004)** and **Singh *et al.* (2005)** in Sahiwal and **Mukherjee (2005), Panja (1997)** and **Singh (1995)** in crossbred cattle.

4.2.6 First Dry Period (FDP)

The heritability estimate of FDP was found to be 0.27 ± 0.11 (Table 4.3). The estimates of heritability similar to the present study were observed by **Raja (2004), Mohanty (2001)** and **Khan *et al.* (1992)** in Sahiwal and **Saha (2001), Panja (1997)** and **Singh and Tomar (1991)** in crossbred cattle. However, the lower estimates of heritability than the present study were reported by **Rehman *et al.* (2006)** and **Javed *et al.* (2000)** in Sahiwal and **Mukherjee (2005)** in crossbred cattle and the higher estimates of heritability for this trait than the present study were observed by **Gaur (2003)** in crossbred cattle. The result of the present study revealed the moderate value of heritability for this trait indicating little influence of genetic factor over this trait. Hence, this trait can be improved only through improving the environmental condition by improving health, housing, feeding and management practices.

4.2.7 First Service Period (FSP)

The heritability estimate of FSP was found to be 0.19 ± 0.10 (Table 4.3). The estimates of heritability similar to the present study were observed by **Singh and Singh (2016)** and **Banik (2004)** in Sahiwal and **Saha (2001)** in crossbred cattle. However, the lower estimates of heritability than the present study were reported by **Rehman *et al.* (2008)** in Sahiwal and **Mukherjee (2005)** in crossbred cattle, while higher value of the heritability was reported by **Raja (2004)** in Sahiwal and **Gaur (2003)** and **Panja (1997)** in crossbred cattle.

4.2.8 First Lactation Milk Yield/First Lactation Length (FLMY/FLL)

The heritability of FLMY/FLL was found 0.31 ± 0.11 (Table 4.3). However, **Dash (2014)** and **Nehra (2012)** found a higher value, 0.40 ± 0.09 and 0.61 ± 0.15, respectively, of heritability than the present study.

4.2.9 First Lactation Milk Yield/First Calving Interval (FLMY/FCI)

The heritability estimate of FLMY/FCI was observed as 0.38 ± 0.12 (Table 4.3). **Dash (2014)** (0.44 ± 0.10) and **Nehra (2012)** (0.61 ± 0.15) found a higher estimate of heritability for this trait.

4.3 Genetic and Phenotypic Correlation among First Lactation Traits

Most of the economic traits are expected to be correlated to some extent with one another genetically and phenotypically due to their biochemical and physiological interdependence via various phenomena within an individual. The genetic and environmental association between two traits provide a phenotypic correlation with the assumption that there is no genotype and environmental interaction. Pleiotropy and the linkage between two genes are the main causes of genetic correlation.

The genetic and phenotypic correlations estimated among first lactation traits have been summarized in table 4.4.

4.3.1 First lactation 305 days milk yield with other traits

FL305DMY showed very high and significant genetic correlations with FLMY, FLL, FLMY/FLL and FLMY/FCI as 1.0 ± 0.025, 0.67 ± 0.25, 0.99 ± 0.03 and 0.96 ± 0.04, respectively. However, FL305DMY showed negative and non-significant genetic correlations with reproductive traits like AFC, FCI, FDP and FSP as -0.37 ± 0.25, -0.13 ± 0.28, -0.51 ± 0.28 and -0.04 ± 0.30, respectively. The phenotypic correlation of FL305DMY with FLMY (0.89 ± 0.008), FLL (0.38 ± 0.04), FLMY/FLL (0.86 ± 0.01) and FLMY/FCI (0.84 ± 0.01) were high and significant, while FL305DMY had a non-significant phenotypic correlation with AFC (0.02 ± 0.04), FCI (0.13 ± 0.04), and FSP (0.15 ± 0.04).

The present study showed negative and highly significant ($P \leq 0.01$) phenotypic correlation between FL305DMY and FDP (-0.23 ± 0.03). Based on the higher estimate of the genetic correlation between FL305DMY and FLMY it can be concluded that these two traits are influenced by the same genes that can be used to improve milk production through indirect selection.

Dash (2014), Nehra (2012) and **Mukherjee (2005)** also found the almost similar result to the present study. **Dash (2014)** and **Mukherjee (2005)** also reported the genetic correlation of FL305DMY with FSP, FLL, FCI and FDP non-significant and **Nehra (2012)** also reported a high and significant genetic and phenotypic correlation of FL305DMY with FLMY, FLMY/FLL and FLMY/FCI. The genetic and phenotypic correlations similar to the present study were also reported by **Raja (2004)**, **Manoj (2009), Kannan (2002)** and **Mohnaty (2001),** whereas **Banik (2004)** reported a non-significant genetic correlation between FL305DMY and FLL.

Table 4.4 Genetic and phenotypic correlation among first lactation production and reproduction traits in Sahiwal and crossbred cattle

TRAITS	Correlation	FL305DMY	FLMY	FLL	AFC	FCI	FDP	FSP	FLMY/ FLL	FLMY/FCI
FL305DMY	r_g									
	r_p									
FLMY	r_g	1.0 ± .025**								
	r_p	0.89 ± 0.008**								
FLL	r_g	0.67 ± 0.25*	0.72 ± 0.22**							
	r_p	0.38 ± 0.04**	0.54 ± 0.03**							
AFC	r_g	-0.37 ± 0.25	-0.29 ± 0.28	0.03 ± 0.34						
	r_p	0.02 ± 0.04	0.05 ± 0.04	0.05 ± 0.04						
FCI	r_g	-0.13 ± 0.28	-0.13 ± 0.31	-0.06 ± 0.40	0.43 ± 0.28					
	r_p	0.13 ± 0.04*	0.31 ± 0.04**	0.46 ± 0.03**	0.11 ± 0.04					
FDP	r_g	-0.51 ± 0.28	-0.56 ± 0.30	-0.63 ± 0.38	0.49 ± 0.26	0.81 ± 0.13**				
	r_p	-0.23 ± 0.03**	-0.16 ± 0.04**	-0.07 ± 0.04	0.12 ± 0.04**	0.68 ± 0.02**				
FSP	r_g	-0.04 ± 0.30	-0.03 ± 0.34	0.02 ± 0.43	0.33 ± 0.30	0.96 ± 0.02**	0.70 ± 0.18**			
	r_p	0.15 ± 0.04**	0.33 ± 0.04**	0.47 ± 0.03**	0.08 ± 0.04*	0.96 ± 0.003**	0.65 ± 0.02**			
FLMY/FLL	r_g	0.99 ± 0.03**	0.96 ± 0.04**	0.50 ± 0.34	-0.50 ± 0.27	-0.17 ± 0.31	-0.48 ± 0.30	-0.09 ± 0.33		
	r_p	0.86 ± 0.01**	0.86 ± 0.01**	0.07 ± 0.04	0.02 ± 0.04	0.08 ± 0.04	-0.18 ± 0.04**	0.10 ± 0.04*		
FLMY/FCI	r_g	0.96 ± 0.04**	0.96 ± 0.06**	0.67 ± 0.28*	-0.42 ± 0.25	-0.41 ± 0.31	-0.71 ± 0.34*	-0.29 ± 0.33	0.92 ± 0.06**	
	r_p	0.84 ± 0.01**	0.78 ± 0.02**	0.24 ± 0.04**	-0.03 ± 0.04	-0.28 ± 0.04**	-0.57 ± 0.03**	-0.25 ± 0.04**	0.79 ± 0.02**	

** Significant at P≤0.01 * Significant at P≤0.05

4.3.2 First lactation milk yield with other traits

FLMY showed positive and significant genetic correlations with FLL, FLMY/FLL and FLMY/FCI as 0.72 ± 0.22, 0.96 ± 0.04 and 0.96 ± 0.06, while the negative and non-significant genetic correlation with AFC (-0.29 ± 0.28) and FDP (-0.56 ± 0.30). The genetic correlations of FLMY with FCI (-0.13 ± 0.31) and FSP (-0.03 ± 0.34) were found very low and non-significant. The present study showed a significant phenotypic correlation of FLMY with all the other traits except AFC (0.05 ± 0.04). **Kumar *et al.* (2011)** and **Singh and Singh (2016)** also found the negative and non-significant genetic correlation between FLMY and AFC. Similar findings were reported by **Kumar *et al.* (2011), Banik (2004)** and **Singh (1992)** in Sahiwal cattle and **Dash (2014), Nehra (2012)** and **Mukherjee (2005)** in crossbred cattle.

4.3.3 First lactation length with other traits

The estimates of genetic correlations of FLL with AFC, FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were found as 0.03 ± 0.34, -0.06 ± 0.40, -0.63 ± 0.38, 0.02 ± 0.43, 0.50 ± 0.34 and 0.67 ± 0.28, respectively. The non-significant genetic correlation among these traits was reported by **Mohanty (2001), Kannan (2002), Kumar (2003) and Banik (2004).** The estimates of phenotypic correlations of FLL with AFC, FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were 0.05 ± 0.04, 0.46 ± 0.03, -0.07 ± 0.04, 0.47 ± 0.03, 0.07 ± 0.04 and 0.24 ± 0.04, respectively. **Banik (2004)** and **Kumar *et al.* (2011)** also found a negative genetic and phenotypic correlation between FLL and FDP in Sahiwal cattle. Similar results were reported by **Dash (2014), Nehra (2012)** and **Mukherjee (2005).**

4.3.4 Age at first calving with other traits

AFC had non-significant genetic correlations with FCI, FDP, FSP, FLMY/FLL and FLMY/FCI as 0.43 ± 0.28, 0.49 ± 0.26, 0.33 ± 0.30, -0.50 ± 0.27, and -0.42 ± 0.25, respectively and phenotypic correlations were also found non-significant with these traits except FDP. The estimates of phenotypic correlations of FLL with FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were found as 0.11 ± 0.04, 0.12 ± 0.04, 0.08 ± 0.04, 0.02 ± 0.04 and -0.03 ± 0.04, respectively. **Nehra (2012), Kannan (2002), Kumar *et al.* (2011), Kumar (2003)** and **Banik (2004)** also reported non-significant genetic and phenotypic correlation among these traits.

4.3.5 First calving interval with other traits

The genetic correlations of FCI with FDP (0.81 ± 0.13) and FSP (0.96 ± 0.02) was observed to be very high and significant, while non-significant genetic correlations of FCI were observed with FLMY/FLL and FLMY/FCI as -0.17 ± 0.31 and -0.41 ± 0.31, respectively. The highly significant genetic correlation between FCI and FSP was also observed by **Kumar *et al.* (2011).** First calving interval had a high and significant phenotypic correlation with FDP (0.68 ± 0.02), FSP (0.96 ± 0.003) and FLMY/FCI (-0.28 ± 0.04). Highly significant phenotypic correlations among these traits were also observed by **Kumar *et al.* (2011)** and **Banik (2004)**. **Nehra (2012)** also observed a negative phenotypic correlation between FCI and FLMY/FCI but positive correlation between FCI and FDP was reported by **Deb et al. (2008).**

4.3.6 First dry period with other traits

The genetic correlations of FDP with FSP, FLMY/FLL and FLMY/FCI were observed as 0.70 ± 0.18, -0.48 ± 0.30 and -0.71 ± 0.34, respectively. High and positive genetic correlation between FDP and FSP was also observed by **Kumar *et al.* (2011),** whereas **Kannan (2002)** observed a highly negative genetic correlation between these two traits. The phenotypic correlations of FDP with FSP, FLMY/FLL and FLMY/FCI were observed as 0.65 ± 0.02, -0.18 ± 0.04 and -0.57 ± 0.03, respectively. However, **Kumar *et al.* (2011), Kannan (2002)** and **Banik (2004)** observed a highly significant phenotypic correlation between FDP and FSP. A negative genetic correlation between FDP and FLMY/FCI was also observed by **Deb *et al.* (2008).**

4.3.7 First service period with other traits

The genetic correlations of FSP with FLMY/FLL and FLMY/FCI were found as -0.09 ± 0.33 and -0.29 ± 0.33, respectively, and the phenotypic correlations of FSP with these traits were found as 0.10 ± 0.04 and -0.25 ± 0.04, respectively. **Verma *et al.* (2016)** also found a negative phenotypic correlation between FSP and FLMY/FCI.

4.3.8 First lactation milk yield/First lactation length (FLMY/FLL) with FLMY/FCI

A highly significant genetic and phenotypic correlation between FLMY/FLL and FLMY/FCI was found as 0.92 ± 0.06 and 0.79 ± 0.02, respectively. **Dash (2014)** and **Nehra (2012)** also found the high genetic and phenotypic correlation between these two traits.

4.3.9 First lactation milk yield/First calving interval (FLMY/FCI) with other traits

The genetic and phenotypic correlations of FLMY/FCI with all the other traits already have been discussed in above headings.

4.4 Genetic and Phenotypic Trends of Production and Reproduction Traits

The estimation of the genetic trend helps to monitor the efficiency of the breeding program implemented since it corresponds to the changes observed in the average values of reproduction of the animals studied for the traits involved during the selection process. Hudson and Kennedy (1995) suggested that the monitoring and interpretation of genetic trend estimates allow to monitor the efficiency of improvement strategies and to ensure that selection pressure is directed towards traits of economic importance.

The genetic, phenotypic and environmental trends estimated for various first lactation production and reproduction traits have been summarized in table 4.5 for Sahiwal and table 4.6 for crossbred cattle.

4.4.1 Genetic, phenotypic and environmental trends in FL305DMY

The genetic trends were estimated to be 6.26 ± 8.56 kg/year in Sahiwal cattle (Table 4.5) and 67.6 ± 10.30kg/year in crossbred cattle (Table 4.6). The genetic trends were found positive and statistically non-significant in Sahiwal cattle, while highly significant ($P \leq 0.01$) in crossbred cattle.

The positive genetic trends in FL305DMY were also reported by **Parveen *et al.* (2018), Dash *et al*. (2016), Mukherjee (2005), Raja (2004), Raheja (1993)** and **Des Raj (1987).** A positive genetic trend indicates that the selection strategies emphasized more on milk yield. The overall increasing genetic trends were observed for FL305DMY in Sahiwal (Fig 4.1) and crossbred (Fig 4.2).

The phenotypic trends were found as 7.92 ± 8.46 kg/year in Sahiwal and 51.75 ± 5.50 kg/year in crossbred cattle. The phenotypic trend was found positive but statistically non-significant in Sahiwal cattle, while highly significant ($P \leq 0.01$) in crossbred cattle.

The positive phenotypic trends in FL305DMY were also reported by **Dash *et al.* (2016), Sarakul *et al.* (2011), Kaygisiz (2010), Rehman *et al.* (2008), Mukherjee (2005), Chaudhary *et al*. (1994) and Des Raj (1987).** However, **Parveen *et al.* (2018),"Raja (2004)** and **Singh (1995)** found negative phenotypic trends in

FL305DMY. The overall increasing phenotypic trends were observed for FL305DMY in Sahiwal (Fig 4.3) and crossbred cattle (Fig 4.4).

The environmental trends were found as 1.67 ± 1.40 in Sahiwal and -15.90 ± 7.09 in crossbred cattle. The environmental trend was found positive but statistically non-significant in Sahiwal cattle, while negative and significant (P≤ 0.05) in crossbred cattle. **Parveen *et al.* (2018)**, **Ambore *et al.* (2017)** and **Singh *et al.* (2017**) also found negative environmental trends in FL305DMY.

4.4.2 Genetic, phenotypic and environmental trends in FLMY.

The genetic trends of FLMY were found as 2.02 ± 9.29 and 67.5 ± 10.30 kg/year in Sahiwal and crossbred cattle, respectively.

The genetic trends were found positive but statistically non-significant in Sahiwal cattle, while highly significant (P≤ 0.01) in crossbred cattle.

Parveen *et al.* (2018), Chaudhary *et al*. (2014), Nehara (2012), Gaur (2003), Raja (2004), Singh and Nagarcenkar (2000), Singh (1995) and Gupta (1992) also found positive genetic trends, while **Mukherjee (2005) and Gupta(1992)** observed negative genetic trend in FLMY**.** A positive genetic trend indicated that the selection strategies emphasized more on milk yield. The overall increasing genetic trends were observed for FLMY in Sahiwal (Fig 4.1) and crossbred (Fig 4.2).

The phenotypic trends were found as 4.64 ± 9.05 and 70.30 ± 8.78in Sahiwal and crossbred, respectively. A positive and non-significant phenotypic trend was found in Sahiwal, while a highly significant (P≤ 0.01) phenotypic trend was found in crossbred cattle.

The positive phenotypic trends were also observed by **Nehara (2012), Singh and Nagarcenkar (2000), Singh (1995)** and **Murdia and Tripathi (1986),** while negative genetic trends were observed by **Parveen *et al.* (2018)** and **Chaudhary *et al.* (2014)**. The overall increasing phenotypic trends were observed for FLMY in Sahiwal (Fig. 4.3) and crossbred (Fig. 4.4).

The environmental trends were found as 2.56 ± 1.90 and 2.49 ± 4.53 kg/year in Sahiwal and crossbred, respectively. The environmental trends were found positive but statistically non-significant both in Sahiwal and crossbred. **Nehara (2012)** also observed a positive environmental trend for this trait.

Table 4.5 Genetic, phenotypic and environmental trends of production and reproduction traits in Sahiwal cattle

TRAITS	GENETIC TRENDS	PHENOTYPIC TRENDS	ENVIRONMENTAL TRENDS
FL305DMY(Kg)	6.26 ± 8.56	7.92 ± 8.46	1.67 ± 1.40
FLMY(kg)	2.02 ± 9.29	4.64 ± 9.05	2.56 ± 1.90
FLL(days)	-1.53 ± 0.76	-1.35 ± 0.71	0.18 ± 0.22
AFC(days)	-3.24 ± 3.36	-2.20 ± 2.00	1.05 ± 1.16
FCI(days)	1.08 ± 2.00	-0.22 ± 3.54	-1.29 ± 0.24**
FDP(days)	2.57 ± 1.90	1.14 ± 2.03	-1.430 ± 0.47**
FSP(days)	0.16 ± 1.99	-1.17 ± 2.03	-1.33 ± 0.21**
FLMY/FLL	0.02 ± 0.02	0.04 ± 0.02	0.01 ± 0.002**
FLMY/FCI	-0.009 ± 0.02	0.01 ± 0.002	0.02 ± 0.03**

** Significant at P≤0.01 * Significant at P≤0.05

Table 4.6 Genetic, phenotypic and environmental trends of production and reproduction traits in crossbred cattle

TRAITS	GENETIC TRENDS	PHENOTYPIC TRENDS	ENVIRONMENTAL TRENDS
FL305DMY(Kg)	67.6 ± 10.30**	51.75 ± 5.50**	-15.90 ± 7.09*
FLMY(kg)	67.5 ± 10.30**	70.30 ± 8.78**	2.49 ± 4.53
FLL(days)	2.35 ± 0.85**	2.36 ± 0.83*	0.002 ± 0.08
AFC(days)	-12.69 ± 2.50**	-12.81 ± 2.65**	-0.12 ± 0.12
FCI(days)	1.09 ± 1.29	1.26 ± 1.29	0.16 ± 0.06**
FDP(days)	-1.08 ± 0.83	-1.77 ± 0.96	0.67 ± 0.24**
FSP(days)	0.18 ± 1.43	1.03 ± 1.43	1.21 ± 0.40**
FLMY/FLL	0.22 ± 0.02**	0.18 ± 0.02**	-0.04 ± 0.01**
FLMY/FCI	0.15 ± 0.02**	0.13 ± 0.02**	-0.012 ± 0.007

** Significant at P≤0.01 * Significant at P≤0.05

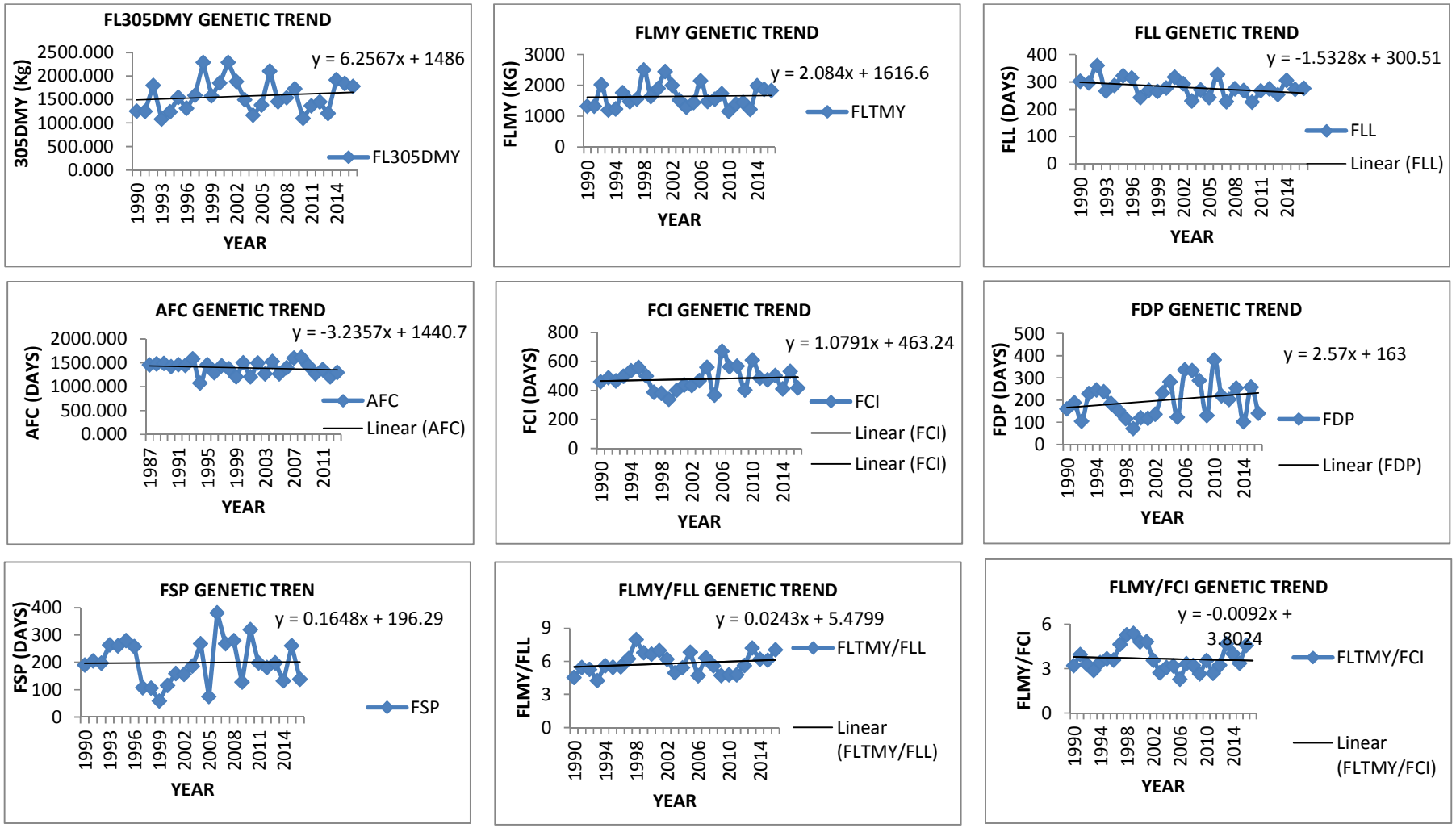

Fig 4.1 Genetic trends of first lactation production and reproduction traits in Sahiwal cattle.

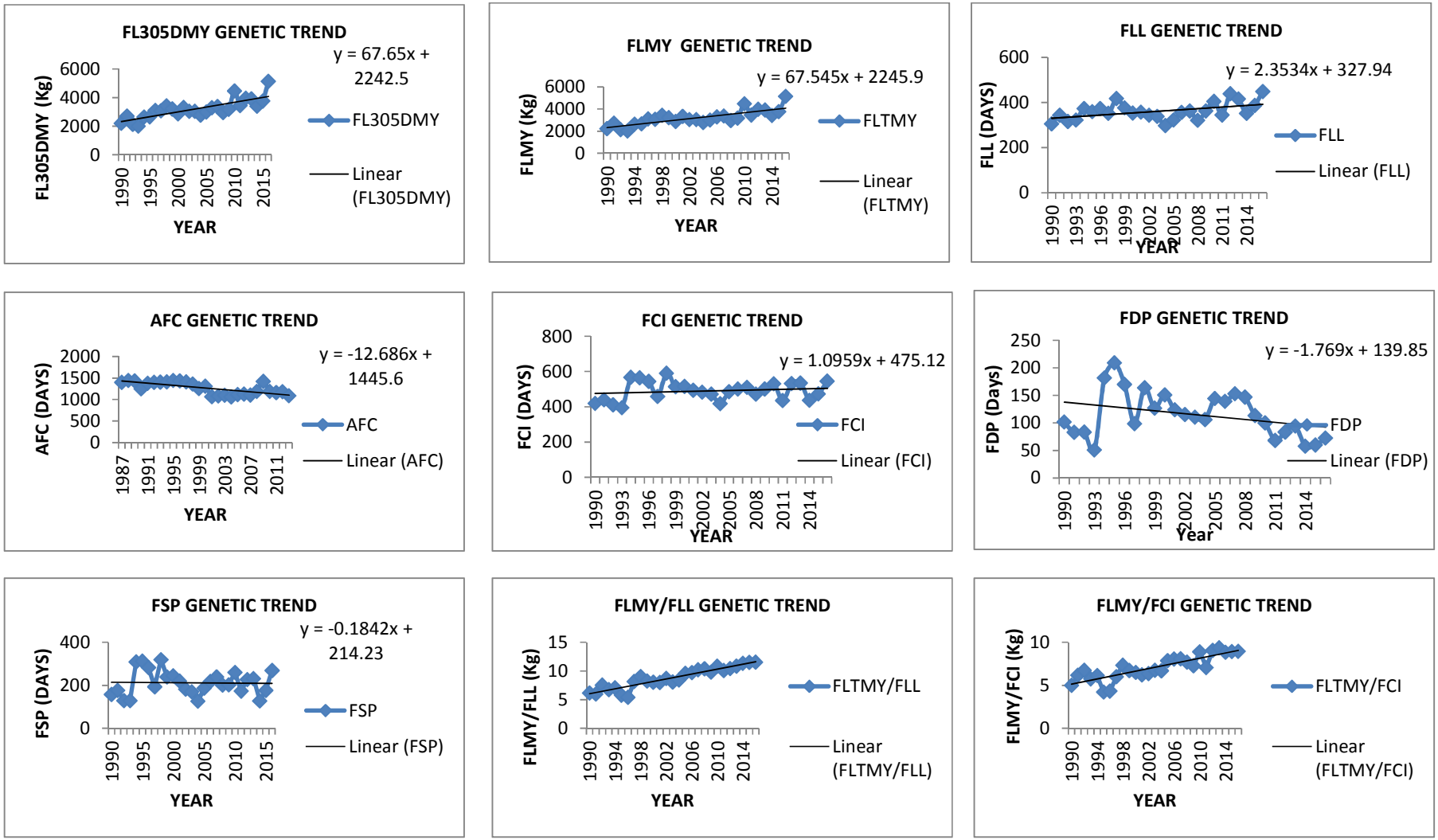

Fig. 4.2 Genetic trends of first lactation production and reproduction traits in crossbred cattle.

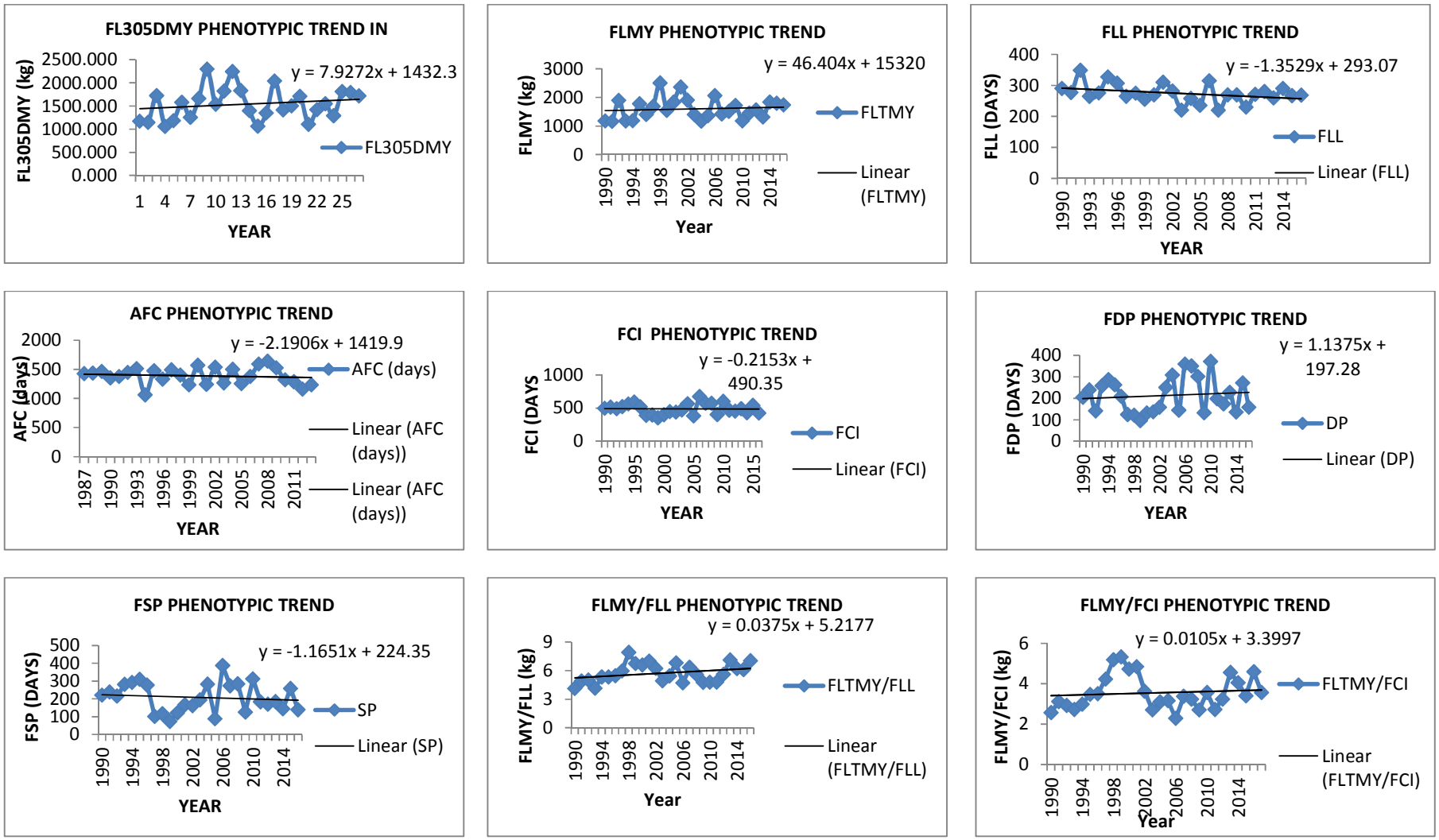

Fig 4.3 Phenotypic trends of first lactation production and reproduction traits in Sahiwal cattle.

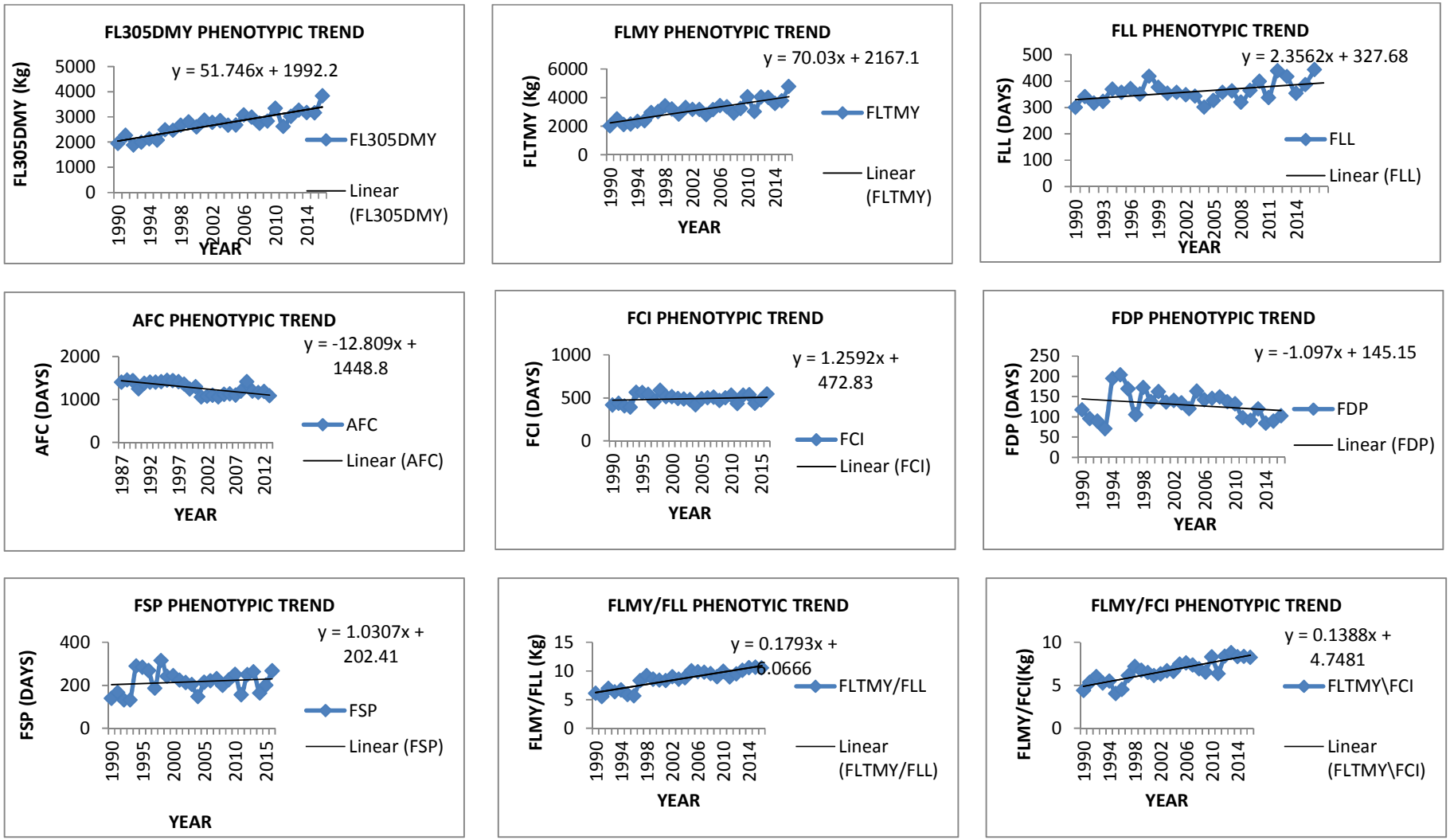

Fig 4.4 Phenotypic trends of first lactation production and reproduction traits in crossbred cattle.

4.4.3 Genetic, phenotypic and environmental trends in FLL

The genetic trends of FLL were found as -1.53 ± 0.76 days/year in Sahiwal and 2.35 ± 0.85days/year in crossbred cattle. A negative and non-significant genetic trend was observed in Sahiwal cattle whereas the positive and highly significant (P≤ 0.01) genetic trend was observed in crossbred cattle.

A similar negative genetic trend in FLL as the present study was observed by **Mukherjee (2005), Raja (2004), Singh (1995)** and **Gupta (1992)**. However, the positive genetic trend in FLL was observed by **Chaudhary *et al.* (2014), Nehara (2012), Rehman *et al.* (2008)** and **Gaur (2003).**

The phenotypic trends of FLL were found as -1.35 ± 0.71 days/ year in Sahiwal and 2.36 ± 0.83 days/year in crossbred cattle. A negative and non-significant phenotypic trend was observed in Sahiwal cattle whereas the positive and highly significant (P≤ 0.01) phenotypic trend was observed in crossbred cattle. A similar negative phenotypic trend in FLL as the present study was observed by **Rehman *et al.* (2008), Mukherjee (2005), Singh (1995) and Gupta (1992)**. However, positive phenotypic trend was observed by **Chaudhary *et al.* (2014), Nehara (2012), Gaur (2003)** and **Herbert (1987)**.

The environmental trends were observed as 0.18 ± 0.22 and 0.002 ± 0.08 days/year in Sahiwal and crossbred cattle, respectively. Environmental trends were statistically non-significant but in positive direction**. Nehara (2012)** also observed a positive environmental trend for this trait.

4.4.4 Genetic, phenotypic and environmental trends in AFC

The genetic trends were estimated to be -3.24 ± 3.36 and -12.69 ± 2.50 days/year in Sahiwal and crossbred cattle, respectively. Genetic trend was statistically non-significant for Sahiwal cattle, while highly significant (P≤ 0.01) for crossbred cattle. Overall, a decreasing genetic trend was observed in Sahiwal (Fig. 4.1) as well as in crossbred cattle (Fig. 4.2).

Negative genetic trends in AFC were also observed by **Ambhore *et al.* (2017), Nehara (2012), Mukherjee (2005), Gupta (1992) and Murdia** and **Tripathi (1991)** whereas**, Chaudhary *et al.* (2014) and Raja (2004)** found positive genetic trends in AFC.

The phenotypic trends of AFC were found as -2.20 ± 2.00 days/ year in Sahiwal and -12.81 ± 2.65 days/year in crossbred cattle. A negative and non-significant phenotypic trend was observed in Sahiwal cattle whereas the highly significant ($P \leq 0.01$) phenotypic trend was observed in crossbred cattle.

The similar negative phenotypic trend in AFC was also observed by **Chaudhary *et al.* (2014)** and **Acharya and Lush (1968)**. However, the positive phenotypic trend was observed by **Ambhore *et al.* (2017) Nehara (2012), Mukherjee (2005)** and **Gupta (1992).** Overall, decreasing phenotypic trends were observed in Sahiwal (Fig 4.3) and crossbred cattle (Fig. 4.4).

The environmental trends were found as 1.05 ± 1.16 and -0.12 ± 0.12 days/year in Sahiwal and crossbred cattle, respectively. Environmental trends were found non-significant both in Sahiwal and crossbred cattle. **Nehara (2012), Mukherjee (2005)** and **Gupta (1992)** also found positive environmental trends in AFC.

4.4.5 Genetic, phenotypic and environmental trends in FCI

The genetic trends of FCI were found as 1.08 ± 2.00 and 1.09 ± 1.290 days/year in Sahiwal and crossbred cattle, respectively. The genetic trends were found positive and statistically non-significant in Sahiwal and crossbred cattle.

Ambhore *et al.* (2017), Rehman *et al.* (2008) and **Singh (1995)** also found positive genetic trends, while **Chaudhary *et al.* (2014)**, **Nehara (2012), Mukherjee (2005)** and **Raja (2004)** observed negative genetic trend in FCI**.** The overall increasing genetic trends were observed for FCI in Sahiwal (Fig 4.1) and crossbred (Fig 4.2).

The phenotypic trends of FCI were found as -0.22 ± 3.54 days/ year in Sahiwal and 1.26 ± 1.29 days/year in crossbred cattle. A negative and non-significant phenotypic trend was observed in Sahiwal cattle whereas the positive and non-significant phenotypic trend was observed in crossbred cattle.

A negative phenotypic trend in FCI was observed by **Mukherjee (2005), Gaur (2003)** and **Singh (1995).** However, positive phenotypic trend was reported by **Ambhore *et al.* (2017), Chaudhary *et al.* (2014)**, **Nehara (2012)** and **Rehman *et al.* (2008).** Overall a decreasing phenotypic trend of FCI was observed in Sahiwal (Fig 4.3), while an increasing phenotypic trend was observed in crossbred cattle (fig 4.4).

The environmental trends were found as -1.29 ± 0.24 and 0.16 ± 0.06 days/year in Sahiwal and crossbred cattle, respectively. Environmental trends were found statistically highly significant (P≤ 0.01) in Sahiwal as well as in crossbred cattle. **Nehara (2012)** and **Chaudhary *et al.* (2014)** also reported positive environmental trend for this trait.

4.4.6 Genetic, phenotypic and environmental trends in FDP

The genetic trends of FDP were found as 2.57 ± 1.90 and -1.08 ± 0.83 days/year in Sahiwal and crossbred cattle, respectively. The genetic trends were found positive in Sahiwal whereas negative and statistically non-significant in crossbred cattle.

Chaudhary *et al.* (2014) and **Mukherjee (2005)** also reported negative genetic trend for FDP. However, **Rehman *et al.* (2008)** and **Rehman and khan (2012)** found a positive genetic trend for FDP. Overall an increasing genetic trend of FDP was observed in Sahiwal (Fig 4.1), while a decreasing genetic trend was observed in crossbred cattle (Fig 4.2).

The phenotypic trends of FDP were found as 1.14 ± 2.03 days/ year in Sahiwal and -1.77 ± 0.96 days/year in crossbred cattle. A positive and non-significant phenotypic trend was observed in Sahiwal cattle whereas the negative and non-significant phenotypic trend was observed in crossbred cattle.

A positive phenotypic trend in FDP was observed by **Chaudhary *et al.* (2014), Rehman and khan (2012), Rehman *et al.* (2008)** and **Mukherjee (2005).** Overall, an increasing phenotypic trend of FDP was observed in Sahiwal (Fig 4.3), while a decreasing genetic trend was observed in crossbred cattle (Fig 4.4).

The environmental trends were found as -1.430 ± 0.47 and 0.67 ± 0.24 days/year in Sahiwal and crossbred cattle, respectively. Environmental trends were found statistically highly significant (P≤ 0.01) in Sahiwal as well as in crossbred cattle. **Chaudhary *et al.* (2014)** also reported positive environmental trend for this trait.

4.4.7 Genetic, phenotypic and environmental trends in FSP

The genetic trends of FSP were found as 0.16 ± 1.99 and 0.18 ± 1.43 days/year in Sahiwal and crossbred cattle, respectively. The genetic trends were found positive and statistically non-significant in Sahiwal as well as in crossbred cattle.

Dash *et al.* (2016), Rehman *et al.* (2008) and **Mukherjee (2005)** also reported positive genetic trend for FSP whereas **Ambhore *et al.* (2017)**, **Chaudhary *et al.* (2014)** and **Kurian *et al.* (2011)** reported negative genetic trend. Overall, an increasing genetic trend was observed in present study.

The phenotypic trends of FSP were found as -1.17 ± 2.03 days/ year in Sahiwal and 1.03 ± 1.43 days/year in crossbred cattle. A negative phenotypic trend was observed in Sahiwal cattle whereas the positive and non-significant phenotypic trend was observed in crossbred cattle.

A negative phenotypic trend in FSP was also observed by **Ambhore *et al.* (2017).** However**, Chaudhary *et al.* (2014), Rehman *et al.* (2008)** and **Mukherjee (2005)** observed positive phenotypic trend.

The environmental trends were found as -1.33 ± 0.21 and 1.21 ± 0.40 days/year in Sahiwal and crossbred cattle, respectively. Environmental trends were found statistically highly significant (P≤ 0.01) in Sahiwal as well as in crossbred cattle. **Chaudhary *et al.* (2014)** also reported positive environmental trend for this trait.

4.4.8 Genetic, phenotypic and environmental trends in FLMY/FLL

The genetic trends of FLMY/FLL were found as 0.02 ± 0.02 and 0.22 ± 0.02 kg/year in Sahiwal and crossbred cattle, respectively. The genetic trends were found positive but statistically non-significant in Sahiwal cattle, while highly significant (P≤ 0.01) in crossbred cattle. **Nehara (2012)** and **Chaudhary *et al.* (2014)** also reported positive genetic trend for this trait. Overall, an increasing genetic trend was observed in Sahiwal (Fig 4.1) as well as in crossbred animal (Fig 4.2).

The phenotypic trends of FLMY/FLL were found as 0.04 ± 0.02 and 0.18 ± 0.02 kg/year in Sahiwal and crossbred cattle, respectively. The phenotypic trends were found positive but statistically non-significant in Sahiwal cattle, while highly significant (P≤ 0.01) in crossbred cattle.

Overall an increasing phenotypic trend was observed in Sahiwal (Fig 4.3) as well as in crossbred cattle (Fig 4.4). **Nehara (2012)** also reported positive phenotypic trend, while **Chaudhary *et al.* (2014)** reported negative phenotypic trend for this trait.

The environmental trends of FLMY/FLL were found as 0.01 ± 0.002 and -0.04 ± 0.01 kg/year in Sahiwal and crossbred cattle, respectively. Environmental trends were found statistically highly significant (P≤ 0.01) in Sahiwal as well as in crossbred cattle. **Chaudhary *et al.* (2014)** also reported negative environmental trend for this trait.

4.4.9 Genetic, phenotypic and environmental trends in FLMY/FCI

The genetic trends of FLMY/FCI were found as -0.009 ± 0.02 and 0.15 ± 0.02 kg/year in Sahiwal and crossbred cattle, respectively. The genetic trends were found statistically non-significant in Sahiwal cattle, while highly significant (P≤ 0.01) in crossbred cattle. Overall, increasing trends were observed for FLMY/FCI in Sahiwal (Fig. 4.1) as well as in crossbred (Fig. 4.2). **Nehara (2012)** and **Chaudhary *et al.* (2014)** also reported positive genetic trend for this trait. However, **Murdia (1989)** reported negative genetic trend for this trait.

The phenotypic trends of FLMY/FLL were found as 0.01 ± 0.002 and 0.13 ± 0.02 kg/year in Sahiwal and crossbred cattle, respectively. The phenotypic trends were found positive but statistically non-significant in Sahiwal cattle, while highly significant (P≤ 0.01) in crossbred cattle.

Overall, an increasing phenotypic trend was observed in Sahiwal (Fig 4.3) as well as in crossbred cattle (Fig 4.4). **Nehara (2012)** also reported positive phenotypic trend for this trait. However, **Chaudhary *et al.* (2014)** reported negative phenotypic trend.

The environmental trends of FLMY/FCI were found as 0.02 ± 0.03 and -0.012 ± 0.007 kg/year in Sahiwal and crossbred cattle, respectively. The environmental trends were found positive but statistically highly significant (P≤ 0.01) in Sahiwal cattle, while negative and non-significant in crossbred cattle. **Chaudhary *et al.* (2014)** also reported negative environmental trend for this trait.

Summary and Conclusions

Chapter 5 SUMMARY AND CONCLUSION

The present investigation was carried out to study the genetic and phenotypic trends on production and reproduction traits in Sahiwal and crossbred cattle the data for which were collected from history sheets and milk record registers maintained at Instructional Dairy Farm, Nagla of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The breeding data used in the present study relates to 568 Sahiwal and crossbred cattle sired by 49 sires. The data spread over a period of 30 years (1987-2016). Cows having incomplete and abnormal lactation were excluded. The recorded data were used to estimate the least-squares means for first lactation traits, effect of genetic and non-genetic factors, genetic and phenotypic parameters of first lactation traits and genetic and phenotypic trends of production and reproduction traits.

The overall least-squares mean for first lactation traits viz. first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation length (FLL), age at first calving (AFC), first calving interval (FCI), first dry period (FDP), first service period (FSP), first lactation milk yield per day of first lactation length (FLMY/FLL) and first lactation milk yield per day of first calving interval (FLMY/FCI) were found as 2231±65.27 kg, 2453.39±84.33 kg, 317.33±4.15 days, 1303.80±21.06 days, 457.14±8.76 days, 137.66±6.47 days, 184.30±8.24 days, 7.59±0.21 kg and 5.51±0.19 kg, respectively.

The least squares analysis of variance for the first lactation traits showed that the effect due to sire was found significant on all the first lactation traits. The effect due to genetic group was found highly significant on first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation length (FLL), First lactation milk yield per day of first lactation length (FLMY/FLL) and First lactation milk yield per day of first calving interval (FLMY/FCI).The effect due to the period of calving was found highly significant ($P \leq 0.01$) on first lactation length (FLL) whereas non-significant effect was found on all other remaining traits. The effect due to the season of calving on all the first lactation traits was found non-significant. The effect due to the AFC group was found highly significant ($P \leq 0.01$) on first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation milk yield

per day of first lactation length (FLMY/FLL) and first lactation milk yield per day of first calving interval (FLMY/FCI) whereas non-significant effect was found on first lactation length (FLL), age at first calving (AFC), first calving interval (FCI), first dry period (FDP) and first service period (FSP).

The least-squares means revealed that there were no significant differences for almost all the first lactation traits under study for different seasons and period. The highly significant effect of sire on all the first lactation traits indicated that superior sires had been used from time to time for the overall improvement of the herd.

The heritability estimates for first lactation traits viz. first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation length (FLL), age at first calving (AFC), first calving interval (FCI), first dry period (FDP), first service period (FSP), First lactation total milk yield per day of first lactation length (FLMY/FLL) and First lactation total milk yield per day of first calving interval (FLMY/FCI) were observed as 0.41±0.13, 0.30±0.11, 0.15±0.09, 0.33±0.12, 0.23±0.10, 0.27±0.11, 0.19±0.10, 0.31±0.11 and 0.38±0.12, respectively.

FL305DMY showed very high and significant genetic correlations with FLMY, FLL, FLMY/FLL and FLMY/FCI as 1.0±0.025, 0.67±0.25, 0.99±0.03 and 0.96±0.04, respectively. However, FL305DMY showed negative and non-significant genetic correlations with reproductive traits like AFC, FCI, FDP and FSP as -0.37±0.25, -0.13±0.28, -0.51±0.28 and -0.04±0.30, respectively. The phenotypic correlation of FL305DMY with FLMY (0.89±0.008), FLL (0.38±0.04), FLMY/FLL (0.86±0.01) and FLMY/FCI (0.84±0.01) were high and significant, while FL305DMY had a non-significant phenotypic correlation with AFC (0.02±0.04), FCI (0.13±0.04), and FSP (0.15±0.04). The present study showed negative and highly significant ($P \leq 0.01$) phenotypic correlation between FL305DMY and FDP (-0.23±0.03). The genetic and phenotypic correlation of FLL with AFC, FCI, FSP, FLMY/FLL and FLMY/FCI were very low to high (0.02 to 0.67) and were negative for FDP. AFC had positive genetic and phenotypic correlations with FCI, FDP and FSP, while negative with FLMY/FLL and FLMY/FCI. The genetic and phenotypic correlation of FCI with FDP and FSP were high to very high (0.68 to 0.96) and significant but with FLMY/FLL and FLMY/FCI were very low to medium and negative (0.08 to -0.41). The genetic and phenotypic correlations of FDP with FSP were positive and high but with FLMY/FLL

and FLMY/FCI were medium and negative. The genetic and phenotypic correlations of FSP with FLMY/FLL and FLMY/FCI were negatively low to medium (-0.09 to -0.25) and negative. FLMY/FLL had a high and positive genetic and phenotypic correlation with FLMY/FCI.

In Sahiwal cattle, the estimates of genetic trends for first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation length (FLL), age at first calving (AFC), first calving interval (FCI), first dry period (FDP), first service period (FSP), first lactation milk yield per day of first lactation length (FLMY/FLL) and first lactation milk yield per day of first calving interval (FLMY/FCI) were found as 6.26±8.56 kg, 2.02±9.29 kg, -1.53±0.76 days, -3.24±3.36 days, 1.08±2.00 days, 2.57±1.90 days, 0.16±1.99 days, 0.02±0.02 kg and -0.009±0.02 kg, respectively. The present study showed positive and overall increasing genetic trends for FL305DMY, FLMY, FCI, FDP, FSP and FLMY/FLL, while decreasing genetic trends for FLL and AFC. The estimates of phenotypic trends for FL305DMY, FLMY, FLL, AFC, FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were 7.92±8.46 kg, 4.64±9.05 kg, -1.35±0.71 days, -2.20±2.00 days, -0.22±3.54 days, 1.14±2.03 days, -1.17±2.03 days, 0.04±0.02 kg and 0.01±0.002 kg, respectively. Similarly, the environmental trends for these traits were 1.67±1.40 kg, 2.56±1.90 kg, 0.18±0.22 days, 1.05±1.16 days, -1.29±0.24 days, -1.430±0.47 days, -1.33±0.21 days, 0.01±0.002 kg and 0.02±0.03 kg, respectively.

In crossbred cattle the estimates of genetic trends for first lactation 305 days milk yield (FL305DMY), first lactation milk yield (FLMY), first lactation length (FLL), age at first calving (AFC), first calving interval (FCI), first dry period (FDP), first service period (FSP), first lactation milk yield per day of first lactation length (FLMY/FLL) and first lactation milk yield per day of first calving interval (FLMY/FCI) were found as 67.6±10.30 kg, 67.5±10.30 kg, 2.35±0.85 days, -12.69±2.50 days, 1.09±1.29 days, -1.08±0.83 days, 0.18±1.43 days, 0.22±0.02 kg and 0.15±0.02 kg, respectively. The estimates of phenotypic trends for all these traits were 51.75±5.50 kg, 70.30±8.78 kg, 2.36±0.83 days, -12.81±2.65 days, 1.26±1.29 days, -1.77±0.96 days, 1.03±1.43 days, 0.18±0.02 kg and 0.13±0.02 kg, respectively. Similarly, the environmental trends for these traits were -15.90±7.09 kg, 2.49±4.53 kg, 0.002±0.08 days, -0.12±0.12 days, 0.16±0.06 days, 0.67±0.24 days, 1.21±0.40 days, -0.004±0.01 kg and -0.012±0.01 kg, respectively. The present study showed positive

and overall increasing genetic and phenotypic trends for FL305DMY, FLMY, FLL, FCI, FSP, FLMY/FLL and FLMY/FCI.

Based on the results obtained in the present study, the following conclusions were drawn:

- The least-squares means revealed that there were no significant differences for almost all the first lactation traits under study for different seasons and periods which were obvious because standard practices are adopted at the farm and adjustments to any duration are made as and when required.
- The highly significant effect of sire on 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 highly significant effect of AFC group on milk yield in Sahiwal and crossbred cattle. The early calvers produced comparatively lower milk than the optimum calvers.
- The heritability estimates for first lactation traits were observed low to medium which revealed that non-genetic variability in these traits was existing and these traits could be improved through better breeding, feeding and management practices.
- The positive and significant genetic and phenotypic correlation among production traits viz. FL305DMY, FLMY and FLL revealed that these traits are influenced by the same genes and improvement for one trait simultaneously leads to the improvement in other traits.
- The negative and non-significant genetic correlation between FLL and FDP indicate that selection on the basis of one trait could be done up to a desirable limit after that selection process can be relaxed.
- The overall increasing genetic and phenotypic trends for FL305DMY, FLMY, FLL, FCI, FSP, FLMY/FLL and FLMY/FCI indicated that the selection strategies emphasized more on milk yield which is quite obvious as in dairy animals milk production takes precedence over other production traits.
- The AFC showed the negative trends over the years indicating the improvement in reproductive management of the cows.

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VITA

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ABSTRACT

The present study was undertaken on Sahiwal and crossbred 568 cattle sired by 49 sires, maintained at Instructional Dairy Farm, Nagla of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The data spread over a period of 30 years (1987-2016). The study was conducted on least squares means, genetic and phenotypic parameters and genetic and phenotypic trends of first lactation production and reproduction traits.

The overall least-squares means for first lactation traits viz. FL305DMY, FLMY, FLL, FCI, FDP, FSP FLMY/FLL and FLMY/FCI were 2231±65.27 kg, 2453.39±84.33 kg, 317.33±4.15 days, 1303.80±21.06 days, 457.14±8.76 days, 137.66±6.47 days, 184.30±8.24 days, 7.59±0.21 kg and 5.51±0.19 kg, respectively. The heritability estimates for these first lactation traits were as 0.41±0.13, 0.30±0.11, 0.15±0.09, 0.33±0.12, 0.23±0.10, 0.27±0.11, 0.19±0.10, 0.31±0.11 and 0.38±0.12, respectively.

The least-squares analysis of variance for the first lactation traits revealed that the effect due to genetic group was found highly significant on FL305DMY, FLMY, FLL, FLMY/FLL and FLMY/FCI. The effect due to sire was significant on all the first lactation traits. The effect due to the period of calving was also found highly significant ($P \leq 0.01$) on FLL. The effect due to the season of calving on all the first lactation traits was found non-significant. The effect due to the AFC group was found highly significant ($P \leq 0.01$) on FL305DMY, FLMY, FLMY/FLL and FLMY/FCI.

The positive and significant genetic and phenotypic correlation among production traits viz. FL305DMY, FLMY and FLL revealed that these traits are influenced by the same genes and improvement for one trait simultaneously leads to the improvement in other traits. The negative and non-significant genetic correlation between FLL and FDP indicate that selection on the basis of one trait could be done up to a desirable limit after that selection process can be relaxed.

In Sahiwal, the estimates of genetic trends for FL305DMY, FLMY, FLL, AFC, FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were 6.26±8.56 kg, 2.02±9.29 kg, -1.53±0.76 days, -3.24±3.36 days, 1.08±2.00 days, 2.57±1.90 days, 0.16±1.99 days, 0.02±0.02 kg and -0.009±0.02 kg, respectively. The estimates of phenotypic trends for these traits were 7.92±8.46 kg, 4.64±9.05 kg, -1.35±0.71 days, -2.20±2.00 days, -0.22±3.54 days, 1.14±2.03 days, -1.17±2.03 days, 0.04±0.02 kg and 0.01±0.002 kg, respectively.

In crossbred, cattle the estimates of genetic trends for FL305DMY, FLMY, FLL, AFC, FCI, FDP, FSP, FLMY/FLL and FLMY/FCI were 67.6±10.30 kg, 67.5±10.30 kg, 2.35±0.85 days, -12.69±2.50 days, 1.09±1.29 days, -1.08±0.83 days, 0.18±1.43 days, 0.22±0.02 kg and 0.15±0.02 kg, respectively. The estimates of phenotypic trends for all these traits were 51.75±5.50 kg, 70.30±8.78 kg, 2.36±0.83 days, -12.81±2.65 days, 1.26±1.29 days, -1.77±0.96 days, 1.03±1.43 days, 0.18±0.02 kg and 0.13±0.02 kg, respectively.

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शोध शीर्षक	:	''साहिवाल और क्रॉसब्रेड गायों में उत्पादन और प्रजनन लक्षणों के आनुवंशिक रूझानों पर अध्ययन''			
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सारांश

वर्तमान शोध कार्य प्रशिक्षण पशु फॉर्म नगला पंतनगर में ३० वर्षों से (१९८७–२०१६) पोषित ५६८ साहिवाल और क्रॉसब्रेड गायों पर किया गया। यह शोध कार्य प्रथम ब्यांत के गुणों का न्यूनतम वर्ग औसत, अनुवांशिकी एवं प्ररूपी मापदंडों और अनुवांशिकी एवं प्ररूपी रुझान का अनुमान लगाने के लिए किया गया।

प्रथम ब्यांत गुण जैसे प्रथम ब्यांत का ३०५ दिन के लिए दुग्ध उत्पादन, प्रथम ब्यांत का संपूर्ण दुग्ध उत्पादन, प्रथम ब्यांत अवधि, प्रथम ब्यांत उम्र, प्रथम ब्यांत अंतराल, प्रथम शुष्क अवधि, प्रथम सर्विस अवधि, प्रथम ब्यांत अवधि का दैनिक दुग्ध उत्पादन और प्रथम ब्यांत अंतराल का दैनिक दुग्ध उत्पादन का न्यूनतम वर्ग औसत क्रमशः २२३१+६५.२७ किग्रा, २४५३.३९+८५.३३ किग्रा, ३१७.३३+४.१५ दिन, १३०३.८०+२१.०६ दिन, ४५७.१४+८.७६ दिन, १३७.६६+६.४७ दिन, १८४.३०+८.२४ दिन, ७.५९+०.२१ किग्रा और ५.५१+०.१९ किग्रा पाया गया। उपर्युक्त प्रथम ब्यांत गुणों के लिए वंशागतित्व क्रमशः ०.५१+०.१३, ०.३०+०.११, ०.१५+०.०९, ०.३३+०.१२, ०. २३+०.१०, ०.२७+०.११, ०.१९+०.१०, ०.३१+०.११ और ०.३८+०.१२ पाया गया।

उपरोक्त सभी प्रथम ब्यांत गुणों पर सांडों का प्रभाव महत्वपूर्ण पाया गया। ऋतु का प्रभाव किसी भी गुण पर महत्वपूर्ण नहीं पाया गया। प्रथम ब्यांत □यु का प्रभाव प्रथम ब्यांत 305 दिन दुग्ध उत्पादन, प्रथम व्यान संपूर्ण दुग्ध उत्पादन प्रथम ब्यांत अवधि का दैनिक दुग्ध उत्पादन और प्रथम ब्यांत अंतराल का दैनिक दूध उत्पादन पर महत्वपूर्ण पाया गया।

सहिवाल गायों पर अनुवांशिकी रुझान उपरोक्त प्रथम ब्यांत गुणों जैसे प्रथम ब्यांत का 305 दिन के लिए दुग्ध उत्पादन, प्रथम ब्यांत का संपूर्ण दुग्ध उत्पादन, प्रथम ब्यांत अवधि, प्रथम ब्यांत उम्र, प्रथम ब्यांत अंतराल, प्रथम शुष्क अवधि, प्रथम सर्विस अवधि, प्रथम ब्यांत अवधि का दैनिक दुग्ध उत्पादन और प्रथम ब्यांत अंतराल का दैनिक दुग्ध उत्पादन का न्यूनतम वर्ग औसत क्रमशः ६.२६+८.५६ किग्रा, २.०२+९.२९ किग्रा, –१.५३+०.७६ दिन, –३.२४+३.३६ दिन, १.०८+२.०० दिन, २.५७+१.९० दिन, ०.१६+१.९९ दिन, ०.०२+०.०२ किग्रा, और –०.००९+०.०२ किग्रा पाया गया और प्ररूपी रुझान क्रमशः ७.९२+८.४६ किग्रा, ४.६४+९.०५ किग्रा, –१.३५+०.७१ दिन, –२.२०+२.०० दिन, –०.२२+३.५४ दिन, १.१४+२.०३ दिन, –१.१७+२.०३ दिन, ०.०४+०.०२, और ०.०१+०.००२ पाया गया।

क्रॉसब्रेड गायों पर अनुवांशिकी रुझान प्रथम ज्ञात गुणों जैसे प्रथम ब्यांत का 305 दिन के लिए दुग्ध उत्पादन, प्रथम ब्यांत का संपूर्ण दुग्ध उत्पादन, प्रथम ब्यांत अवधि, प्रथम ब्यांत उम्र, प्रथम ब्यांत अंतराल, प्रथम शुष्क अवधि, प्रथम सर्विस अवधि, प्रथम ब्यांत अवधि का दैनिक दुग्ध उत्पादन और प्रथम ब्यांत अंतराल का दैनिक दुग्ध उत्पादन का न्यूनतम वर्ग औसत क्रमशः ६७.६+१०.३० किग्रा, ६७.५+१०.३० किग्रा, २.३५+०.८५ दिन, –१२.६९+२.५० दिन, १.०९+१.२९ दिन, –१.०८+०.८३ दिन, ०.१८+१.४३ दिन, ०.२२+०.०२ किग्रा, और ०.१५+०.०२ किग्रा पाया गया और प्ररूपी रुझान क्रमशः ५१.७५+५.५० किग्रा, ७०.३०+८.७८ किग्रा, २.३६+०.८३ दिन, –१२.८१+२.६५ दिन, १.२६+१.२९ दिन, –१.७७+०.९६ दिन, १.०३+१.४३ दिन, ०.१८+०.०२, और ०.१३+०.०२ पाया गया।

30/11/19

(सुनील कुमार)
सलाहकार

(संजय दत्त गहतोड़ी)
लेखक