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Genetic analysis of first lactation production and fertility traits in Karan Fries cattle

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ABSTRACT

The present investigation encompasses the genetic analysis of first lactation production and fertility performance of Karan Fries cattle. Data were collected on 1,988 cows maintained at National Dairy Research Institute (NDRI), Karnal, Haryana over a period of 34 years (1978 to 2012). Least squares analysis was carried out to study the effect of non-genetic factors, viz. season of first calving (SC), period of first calving (PC), genetic group (GG) and age at first calving group (AFCG) on first lactation fertility and production traits. Least squares means of age at first calving (AFC), first calving to first service (FCFS), first service period (FSP), first lactation length (FLL), first calving interval (FCI), first lactation 305 day or less milk yield (F305MY), first lactation total milk yield (FTMY), milk yield per day of first lactation length (MY/FLL), milk yield per day of first calving interval (MY/FCI) and first lactation daughter pregnancy rate (FDPR) were 957.48±6.54 days, 79.46±3.58 days, 130.03±4.43 days, 347.02±5.51 days, 415.47±5.21 days, 3,213.91±47.61 kg, 3,760.49±74.27 kg, 10.49±0.12 kg/day, 9.14±0.13 kg/day and 0.33±1.42, respectively. Overview of least squares analysis regarding first lactation traits indicated that most of the non-genetic factors excepting AFC group, significantly affected the performance of the animal. Results revealed the superiority of F_1 over other GG of Karan Fries cows indicating a significant effect of heterosis. Heritability estimated by both analysis of variance and average information restricted maximum likelihood methods indicated that the fertility traits were less affected by additive gene action; the estimates for production traits indicated higher role of additive gene action. Both phenotypic and genetic correlation estimates indicated antagonistic association between fertility and production traits.

Key words: First lactation, Genetic parameters, Karan Fries, Least squares.

Genetic evaluation of dairy cattle needs to be efficient and accurate by considering appropriate factors (genetic and non-genetic) in linear models of estimation of variance components. Identification of such factors is of primary importance for the animal breeder so that the necessary adjustment of animal breeding data can be carried out before estimation of genetic parameters. Fertility is one of the most critical factors influencing the biological and financial performance of animal production systems and genetic improvement of lines (Feugang *et al.* 2009). It is a complex trait affected by both genetic and non-genetic factors. Genetic analysis indicated the fertility traits to be lowly heritable, further, the estimates from a number of studies present unfavourable genetic correlations between various fertility and production traits (Philipsson *et al.* 1994). Identification of significant factors affecting the production and fertility performance of dairy cattle would not only help in making important decisions regarding dairy management, but it would also help in considering these effects in statistical models for estimation of genetic parameters. The decline in fertility is expected to cause a decline in lifetime production performance of dairy cattle. The present investigation was, therefore, designed to study the effects of various genetic and non-genetic factors as well as estimation of genetic parameters for fertility and production performance of Karan Fries cattle.

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MATERIALS AND METHODS

Data were collected on first lactation fertility and production performance of Karan Fries cattle, over a period of 32 years (1981 to 2012) maintained at National Dairy Research Institute (NDRI), Karnal, Haryana. Cows completing at least 1 lactation were considered in the study. First lactation performance records of 1,988 Karan Fries cows sired by 186 bulls were utilized. Traits analyzed were age at first calving (AFC), first service period (FSP), first calving interval (FCI), first calving to first service (FCFS), first lactation daughter pregnancy rate (FDPR), first lactation length (FLL), first lactation 305 day or less milk yield (F305MY), first lactation total milk yield (FTMY), milk yield/day of first lactation length (MY/FLL), and milk yield/day of first calving interval (MY/FCI). First Daughter pregnancy rate (FDPR) was calculated by referring to the formula of VanRanden *et al.* (2004). Data on production and fertility performance were classified according to season of first calving (SC), period of first calving (PC), genetic group (GG), age at first calving group (AFCG). The effect of genetic and non-genetic factors on first lactation fertility and production traits was studied using appropriate statistical techniques.

The prevailing climatic conditions in Karnal region were considered as the basis of grouping the total duration of a year into four seasons (winter, summer, rainy and autumn). Since the modifications in management practices in the farm occurred over different years, the resulting cumulative effect of such practices over a period of 5 to 6 years may be significant on any trait. The effect of genetic group was also studied and classification was done on the basis of the level of Holstein inheritance of Karan Fries cows. The animals were classified into groups 1 (F1 crosses), 2 (interbred) and 3 (≥75%). Age at first calving was categorized into age at first calving (AFC) groups, after analyzing the distribution of the AFC in the population, the data on age at first calving was classified into different groups using the class interval formula. Data analysis was carried out using various software packages such as LSMLMW, WOMBAT and SAS 9.3. The study of the effect of various non-genetic factors on fertility and production traits was carried out using the least squares analysis of variance (LSANOVA) for unequal and non-orthogonal data (Harvey 1990). Data pertaining to first lactation fertility and production traits were analyzed as per the following model:

$$Y_{klmno} = \mu + SC_k + PC_l + GG_m + AFCG_n + e_{klmno}$$

where, Y_{klmno}, observation of the o^{th} individual born in k^{th} season, l^{th} period and m^{th} genetic group, n^{th} AFC group; μ, overall mean; SC_k, fixed effect of k^{th} season of calving; PC_l, fixed effect of l^{th} period of calving; GG_m, fixed effect of m^{th} genetic group of animal; $AFCG_n$, fixed effect of n^{th} AFC group; e_{klmno}, Random error; NID $(0, \sigma^2_e)$. Difference of least squares means between subclasses for each effect was tested by Duncan's multiple range test (DMRT).

Estimation of heritability, the phenotypic and genetic correlation was carried out by least squares analysis of variance (LSANOVA) and average information restricted maximum likelihood (AIREML) methods. The model for analysis was similar to the one mentioned in the preceding section; however, in genetic analysis the effect of genetic group was not considered as only the data pertaining to *inter se* mated population (KF × KF) of Karan Fries cattle was considered for genetic analysis.

RESULTS AND DISCUSSION

The effect of genetic and non-genetic factors influencing first lactation production and fertility traits of Karan Fries cows was studied by the least squares analysis (Tables 1, 2). The effect of period of birth and genetic group was highly significant on AFC. The animals born during the second period (1986–90) showed the lowest AFC. Results across three genetic groups revealed that F_1 cows had the lowest AFC and cows (the offspring of *inter se* mating) had the highest AFC. Period of first calving had a highly significant effect on FCFS and the cows that calved during the first period (1986–90) had the lowest mean FCFS. The effect of season of first calving and period of first calving was highly significant on FSP. Variation of FSP across different genetic groups was found to be significant. The FSP was lower for the animals which calved during the winter, whereas animals calved during the summer had higher FSP indicating a significant environmental effect on the cyclicity and conception of cows. The cows that calved during the first two periods (1981–85 and 1986–90) had the lower FSP of around 120 days. Cows whose first calving occurred during 2006–12 had highest FSP. The average FSP of F_1 cows was lowest and it was the highest for cows with ≥75% Holstein inheritance.

Period of first calving and genetic group had a significant effect on FLL. Cows calved during 1991–95 had shortest FLL whereas the mean FLL was highest for the cows that calved first during 2006–12. FLL was longer for the cows with higher Holstein inheritance (≥75%); and similar for F_1 as well as interbred cows. Season of first calving, period of first calving and genetic group had highly significant effect on FCI. FCI was lower in rainy and winter calvers and highest for summer calvers. Mean FCI of 403 days was observed for cows whose first calving during the first period (1981–85). FCI of F_1 was lowest and cows with ≥75% Holstein inheritance groups had highest FCI estimates.

Analysis revealed a highly significant effect of the period of calving and genetic group on F305MY. The F305MY was highest for the animals which calved during the period (2006–2012). The F305MY was the highest for the F_1 crossbreds. Period of calving as well as genetic group had highly significant effect on FLTMY. Season of calving, period of calving and genetic group had a highly significant effect on MY/FLL. The effect of AFC group was not significant. The highest MY/FLL was observed during autumn and winter and the lowest in the summer. Among all the periods, the highest MY/FLL was observed in the cows that calved during 2006–12 period. Across different genetic groups, MY/FLL was highest in F_1 and lowest in interbred genetic groups. The effect of period of calving and genetic group was significant on MY/FCI. F_1 cows had the highest performance followed by cows with higher Holstein inheritance (≥75%) and the least performance was observed in the interbred population. Significant effect of period of first calving and genetic group was observed on FDPR. Least estimate of FDPR was obtained for the period 2006–12 and higher for the cows that calved first during the period 1981 to 1986. The estimate of FDPR was highest

Table 1. Least squares means of first lactation production and reproduction traits (AFC, FCFS, FSP, FLL, FCI)

Effects	AFC (days)	FCFS (days)	FSP (days)	FLL (days)	FCI (days)
Overall (μ)	957.48 ± 6.54 (1787)	79.46 ± 3.58 (744)	130.03 ± 4.43 (1015)	347.02 ± 5.51 (1580)	415.47 ± 5.21 (1170)
Season of first calving (SC)					
Winter (Dec-Mar)	953.87 ± 7.64 (659)	80.07 ± 3.90 (330)	123.58^{bc} ± 4.90 (449)	353.38 ± 5.99 (712)	416.52^{b} ± 5.72 (527)
Summer (Apr-Jun)	959.90 ± 8.51 (372)	82.96 ± 4.52 (176)	146.52^{a} ± 5.57 (277)	350.81 ± 6.83 (438)	430.01^{a} ± 6.55 (315)
Rainy (Jul-Sept)	958.15 ± 8.19 (463)	76.78 ± 4.46 (131)	130.05^{b} ± 6.07 (177)	339.69 ± 7.62 (251)	410.14^{bc} ± 7.24 (195)
Autumn (Oct-Nov)	957.98 ± 9.00 (293)	78.04 ± 4.76 (107)	119.96^{c} ± 6.97 (112)	344.21 ± 8.41 (179)	405.20^{c} ± 8.09 (133)
Period of first calving (PC)					
1981-1985	987.61^{a} ± 9.06 (266)	-	120.28^{b} ± 6.09 (163)	339.89^{b} ± 7.48 (251)	403.51^{c} ± 7.20 (179)
1986-1990	880.53^{c} ± 9.54 (314)	69.35^{c} ± 8.15 (26)	119.83^{b} ± 6.68 (210)	342.15^{b} ± 8.25 (286)	409.80^{bc} ± 7.78 (237)
1991-1995	945.25^{b} ± 9.46 (331)	75.91b^{c} ± 4.15 (232)	124.26 ± 6.42 (189)	337.18^{b} ± 7.84 (299)	407.47^{bc} ± 7.48 (228)
1996-2000	956.52^{b} ± 9.16 (295)	80.49^{b} ± 4.37 (137)	137.81^{a} ± 6.54 (146)	346.01^{ab} ± 7.89 (232)	423.42^{ab} ± 7.68 (169)
2001-2005	986.22^{a} ± 9.09 (273)	80.21^{b} ± 3.69 (194)	133.33^{ab} ± 6.09 (152)	353.31^{ab} ± 7.38 (254)	416.02^{bc} ± 7.18 (179)
2006-2012	988.72^{a} ± 9.07 (308)	91.36^{a} ± 4.19 (155)	144.68^{a} ± 6.39 (155)	363.61^{a} ± 7.72 (258)	432.59^{a} ± 7.55 (178)
Genetic group (GG)					
F_1	877.63^{b} ± 14.94 (67)	71.64 ± 6.13 (42)	111.32^{c} ± 9.51 (47)	334.53^{b} ± 12.50 (60)	384.95^{a} ± 11.19 (53)
Interbred	1001.87^{a} ± 3.18 (1619)	81.61 ± 2.04 (676)	129.60^{b} ± 2.47 (911)	331.23^{b} ± 2.98 (1426)	414.47^{c} ± 2.90 (1051)
HF × KF	992.92^{a} ± 12.67 (101)	85.14 ± 7.67 (26)	149.17^{a} ± 8.86 (57)	375.30^{a} ± 10.33 (94)	446.99^{b} ± 10.41 (66)
Age at first calving group (AFCG)					
714 - 819	-	72.93 ± 6.02 (48)	122.52 ± 8.00 (78)	353.35 ± 9.87 (115) (115)	413.78 ± 9.30 (92) (92)
820 - 872	-	82.33 ± 4.88 (80)	130.82 ± 6.37 (129)	340.68 ± 8.28 (177)	409.14 ± 7.68 (142)
873 - 925	-	76.65 ± 4.85 (94)	126.01 ± 6.44 (150)	339.4 ± 7.91 (221)	408.79 ± 7.58 (168)
926 - 978	-	79.99 ± 5.01 (105)	138.81 ± 6.50 (163)	345.05 ± 7.91 (255)	426.18 ± 7.54 (195)
979 - 1031	-	78.66 ± 4.82 (119)	129.14 ± 6.60 (153)	352.66 ± 8.05 (244)	415.78 ± 7.73 (176)
1032 - 1084	-	80.32 ± 5.39 (95)	127.35 ± 7.34 (116)	346.98 ± 8.80 (182)	416.43 ± 8.52 (133)
1085 - 1137	-	84.32 ± 5.83 (68)	135.31 ± 8.25 (86)	358.55 ± 9.74 (143)	416.29 ± 9.82 (96)
1138 - 1349	-	80.50 ± 4.92 (135)	130.29 ± 6.70 (140)	339.52 ± 8.04 (243)	417.36 ±7.79 (168)

*Figures in parentheses are the number of observations and dissimilar superscript indicates significant ($P<0.05$) difference of means.

for F_1 cows and lower for the cows that had ≥75% Holstein inheritance.

Significant effect of period of birth on AFC was reported by Sahana and Gurnani (2000) in Karan Fries cows. In the same crossbreed, Divya (2012) found that the differences in FSP were significant for different periods and non-significant in different seasons and AFC groups. Sahana and Gurnani (2000) observed the significant effect of AFC group on FSP in Karan Fries cows. In FLL, Sivakumar (1998) found the significant effect of season of first calving and period of first calving. Sahana and Gurnani (2000) observed the significant effect of AFC group on FLL. Divya

Table 2. Least squares means of first lactation reproduction and production traits (F305MY, FTMY, MY/FLL, MY/FCI, FDPR)

Effects	F305MY (kg)	FTMY (kg)	MY/FLL (kg/day)	MY/FCI (kg/day)	FDPR
Overall (μ)	3213.91 ± 47.61 (1553)	3760.49 ± 74.27 (1596)	10.49 ± 0.12 (1574)	9.14 ± 0.13 (1223)	0.33 ± 1.42 (1137)
Season of first calving (SC)					
Winter (Dec-Mar)	3220.61 ± 50.86 (711)	3831.00 ± 80.33 (717)	10.66^{a} ± 0.13 (710)	9.17 ± 0.14 (553)	0.34 ± 1.56 (513)
Summer (Apr-Jun)	3139.31 ± 57.77 (428)	3713.93 ± 91.48 (444)	10.25^{b} ± 0.15 (443)	9.04 ± 0.16 (329)	0.29 ± 1.82 (301)
Rainy (Jul-Sept)	3216.79 ± 64.21 (251)	3692.65 ± 101.06 (260)	10.40^{ab} ± 0.16 (256)	9.14 ± 0.17 (208)	0.35 ± 1.98 (196)
Autumn (Oct-Nov)	3278.92 ± 73.51 (163)	3804.36 ± 113.58 (175)	10.65^{a} ± 0.19 (165)	9.22 ± 0.20 (133)	0.35 ± 2.28 (127)
Period of first calving (PC)					
1981-1985	3260.67^{b} ± 62.90 (251)	3723.36^{b} ± 99.77 (253)	10.78^{b} ± 0.16 (254)	9.37^{b} ± 0.17 (186)	0.42^{a} ± 2.01 (176)
1986-1990	3261.19^{b} ± 69.98 (283)	3815.49^{b} ± 109.48 (295)	10.71^{b} ± 0.18 (289)	9.20^{b} ± 0.19 (240)	0.39^{ab} ± 2.22 (214)
1991-1995	3199.85^{b} ± 67.43 (284)	3731.82^{b} ± 104.99 (300)	10.53^{b} ± 0.17 (288)	9.26^{b} ± 0.18 (227)	0.33^{bc} ± 2.12 (209)
1996-2000	2859.23^{c} ± 65.81 (233)	3430.46^{c} ± 103.94 (246)	9.31^{c} ± 0.17 (242)	8.24^{c} ± 0.18 (186)	0.28^{cd} ± 2.08 (173)
2001-2005	3209.60^{b} ± 63.05 (246)	3745.24^{b} ± 99.40 (250)	10.40^{b} ± 0.16 (244)	9.02^{b} ± 0.17 (193)	0.32^{bcd} ± 1.99 (174)
2006-2012	3492.91^{a} ± 65.82 (256)	4116.55^{a} ± 104.91 (252)	11.23^{a} ± 0.17 (257)	9.78^{a} ± 0.18 (191)	0.25^{d} ± 2.04 (191)
Genetic group (GG)					
F_1	3365.92^{a} ± 108.73 (55)	3933.71^{a} ± 167.87 (59)	11.17^{a} ± 0.29 (52)	9.78^{a} ± 0.28 (51)	0.42^{a} ± 3.13 (54)
Interbred	3004.21^{c} ± 24.91 (1409)	3343.62^{b} ± 39.46 (1446)	9.88^{c} ± 0.06 (1434)	8.54^{c} ± 0.07 (1103)	0.35^{b} ± 0.81 (1011)
HF × KF	3271.61^{b} ± 87.86 (89)	4004.13^{a} ± 139.79 (91)	10.42^{b} ± 0.23 (88)	9.11^{b} ± 0.25 (69)	0.23^{c} ± 2.80 (72)
Age at first calving group (AFCG)					
714 - 819	3132.80 ± 81.97 (116)	3671.81 ± 131.12 (118)	10.18 ± 0.21 (120)	8.67 ± 0.22 (105)	0.30 ± 2.52 (95)
820 - 872	3151.11 ± 68.46 (180)	3674.17 ± 109.61 (181)	10.33 ± 0.18 (182)	8.98 ± 0.18 (153)	0.33 ± 2.17 (132)
873 - 925	3193.81 ± 67.30 (219)	3708.58 ± 105.63 (225)	10.47 ± 0.17 (220)	9.23 ± 0.18 (174)	0.32 ± 2.12 (158)
926 - 978	3179.29 ± 67.24 (252)	3753.28 ± 105.51 (259)	10.51 ± 0.18 (255)	9.21 ± 0.19 (195) (255)	0.30 ± 2.12 (183)
979 - 1031	3262.57 ± 68.82 (239)	3850.88 ± 107.56 (246)	10.53 ± 0.18 (243)	9.22 ± 0.19 (186)	0.37 ± 2.15 (174)
1032 - 1084	3292.89 ± 74.20 (178)	3806.96 ± 117.15 (184)	10.61 ± 0.19 (182)	9.28 ± 0.21 (143)	0.35 ± 2.37 (132)
1085 - 1137	3309.66 ± 83.41 (134)	3943.68 ± 130.88 (141)	10.71 ± 0.22 (134)	9.44 ± 0.24 (100)	0.36 ± 2.68 (98)
1138 - 1349	3189.17 ± 68.72 (235)	3674.53 ± 107.55 (242)	10.59 ± 0.18 (238)	9.10 ± 0.19 (167)	0.33 ± 2.17 (165)

*Figures in parentheses are the number of observations and dissimilar superscript indicates significant ($P<0.05$) difference of means.

(2012) reported a significant effect of period of calving and non-significant effect of season of calving and age groups on FCI. Rashia (2006) and Kokate (2009) noticed significant effect of season of calving on F305MY. Singh and Gurnani (2004) reported non-significant effect of period of calving and significant effect of season of calving on F305MY in Karan Fries cows. Non-significant effect of season of calving, period of calving and significant effect of AFC group on FDPR was reported by Nehra *et al.* (2012) in the NDRI Karan Fries herd.

Estimation of variance components was conducted by least squares analysis of variance (LSANOVA), whereas

Table 3. Heritability estimates of first lactation fertility and production traits by LSML and AIREML methods

Trait	LSML	AIREML
AFC	0.36±0.08	0.19±0.05
FCFS	0.01±0.09	0.02±0.05
FSP	0.18±0.09	0.12±0.06
FLL	0.13±0.06	0.04±0.04
FCI	0.12±0.07	0.03±0.04
F305MY	0.39±0.09	0.31±0.12
FTMY	0.24±0.07	0.14±0.03
FDPR	0.09±0.07	0.02±0.05
MY/FLL	0.40±0.09	0.23±0.05
MY/FCI	0.44±0.10	0.25±0.06

Results of phenotypic and genetic correlations (Table 4) indicated unfavourable association amongst first lactation production and fertility traits. The results also revealed antagonistic relationship between first lactation production and fertility traits. Similar observation was also reported by Kadarmideen (2004) and VanRaden *et al.* (2004). Nehra *et al.* (2012) reported positive phenotypic and genetic correlations of F305MY with FTMY, FTMY/FLL and FTMY/FCI. Hence, this association indicated that higher F305MY is likely to improve the performance of above mentioned production and production efficiency traits. The genetic correlation of FLL with FTMY and FCI was positive and negative with AFC. Divya (2012) reported negative genetic correlation between the F305MY and fertility traits (AFC, FSP, FCI and FDPR) whereas the phenotypic correlation was positive. Negative phenotypic and genetic correlations were reported for F305MY and FDPR.

Table 4. Estimates of phenotypic and genetic correlations among first lactation fertility and production traits

Trait	FCFS	FSP	FLL	FCI	F305MY	FTMY	MY/FLL	MY/FCI	FDPR
FCFS		0.35**± 0.05	0.32**± 0.05	0.33**± 0.05	0.05± 0.05	0.17**± 0.05	-0.07± 0.05	-0.03± 0.05	-0.44**± 0.05
FSP	0.41± 0.47		0.79**± 0.02	0.97**± 0.01	0.14**± 0.03	0.53**± 0.03	-0.07*± 0.03	-0.05± 0.03	-0.79**± 0.02
FLL	0.88*± 0.40	0.47± 0.25		0.79**± 0.02	0.35**± 0.03	0.73**± 0.02	0.05± 0.03	0.26**± 0.03	-0.67**± 0.04
FCI	0.38± 0.53	0.98**± 0.02	0.49± 0.25		0.15**± 0.03	0.54**± 0.03	-0.07*± 0.03	-0.06± 0.03	-0.77**± 0.03
F305MY	0.28± 0.47	0.09± 0.33	0.38± 0.25	0.17± 0.36		0.76**± 0.02	0.88**± 0.01	0.82**± 0.02	-0.16**± 0.05
FTMY	0.51± 0.40	0.41± 0.27	0.69**± 0.15	0.51*±7 0.2	0.91**± 0.07		0.56**± 0.03	0.62**± 0.02	-0.43**± 0.05
MY/FLL	0.05± 0.45	-0.15± 0.33	0.10± 0.28	-0.06± 0.35	0.96**± 0.03	0.86**± 0.11		0.86**± 0.02	0.07± 0.05
MY/FCI	0.43± 0.45	0.01± 0.32	0.42± 0.25	0.12± 0.36	0.93**± 0.04	0.87**± 0.01	0.96**± 0.03		0.04± 0.05
FDPR	-0.28± 0.96	-1.00± 1.02	-0.67± 0.71	-1.00± 1.11	-0.10± 0.38	-0.41± 0.49	0.13± 0.35	0.04± 0.35	

*Significant at P<0.05 and **highly significant at P<0.01; genetic (below diagonal) and phenotypic (above diagonal) correlation.

AIREML, a modification of the restricted maximum likelihood (REML) was also used for estimation. The results indicated a moderate heritable estimate for AFC. AIREML estimates for all the traits were lower in comparison to that obtained by LSANOVA (Table 3). Divya (2012) reported a higher estimate of heritability for AFC at 0.54±0.17; however the estimates for FCFS, FSP, FCI and FDPR were lower in comparison to those of the present study. Nehra *et al.* (2012) reported similar estimate of AFC (0.43±0.13). Lower heritability estimate (0.21±0.14) for F305MY was obtained by Divya (2012); whereas Nehra *et al.* (2012) reported the trait to be highly heritable (0.48±0.14). The results of the present study indicated that the production efficiency traits were highly heritable. Higher estimates for MY/FLL and MY/FCI were obtained by Nehra *et al.* (2012) (0.61±0.15 and 0.61±0.15, respectively). The estimates of FLL obtained in the current study were similar to that of Sahana and Gurnani (2000) and Nehra *et al.* (2012).

An overview of the least squares analysis regarding the first lactation traits indicated that most of the non-genetic factors considered for analysis, excepting AFC (age at first calving) group, significantly affected the performance of the animal with respect to fertility and production traits. Overall, the results revealed the superiority of F_1 over other genetic groups of Karan Fries cows. Significant effect of season and period was due to variation in availability of fodder, management and environmental conditions during different seasons and periods of calving. LSANOVA and AIREML heritability estimates of fertility traits indicated that these traits were less affected by additive gene action; the estimates for production traits indicated higher role of additive gene action. Antagonistic relationship was observed between first lactation production and fertility traits.

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