



Sire Evaluation by Least Square Analysis for First Lactation Traits in an Organised Herd

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ABSTRACT

The first lactation records of 480 crossbred cattle sired by 41 sires were studied to estimate the average breeding values of crossbred daughters in order to rank the sires based on the estimated breeding values. First lactation traits included were age at first calving (AFC), first service period (FSP), first calving interval (FCI), first lactation period (FLP), first lactation milk yield (FLMY), first lactation 305 days milk yield (FL305DMY), first lactation peak yield (FLPY) and first lactation days to attain peak yield (FLDAPY). The Least squares method (LSM) was used to obtain the estimates of breeding values. The estimated breeding values (EBVs) of sires showed genetic variation between sires for first lactation traits. The estimated breeding values (EBVs) for first lactation traits ranged from 1143.24 days to 1408.33 days. The accuracy of LSM was judged by using Pearson's (product moment) correlation and Spearman (rank) correlation methods. The product moment correlation and rank correlation among the EBVs of sires for various first lactation traits were statistically significant for most of the first lactation traits suggesting that LSM method was accurate and efficient in evaluating as well as ranking the sires for first lactation traits.

HIGHLIGHTS

- Breeding values of sires were estimated based on first lactation traits of their crossbred daughters in order to rank the sires.
- The present investigation was made to select the superior bulls of high genetic merit for breeding and herd improvement and the results were summarised in this manuscript.

Keywords: Crossbred cattle, Breeding values, First lactation traits, Sire evaluation

The crossbreeding among dairy cattle has escalated in recent years and as per 20th livestock census (2019) the female crossbred cattle have reported to be 46.95 million which showed 39% increase over the previous census (2012) where the crossbred cattle population was 33.76 million (DAHD India, 2023). The success of any breed improvement programme depends mainly on the evaluation of sires which involves the estimation of expected breeding value of the daughters on the basis of average breeding values of first lactation traits (Pandey *et al.*, 2013). The expected breeding value of an individual is the average of the breeding values of its parents (Bajetha and Singh, 2015). Prediction of

performances of dairy animals in later lactation can be achieved by studying the first lactation traits because of their high correlation with future performance traits. Ranking of sires for their genetic worth is an important aspect in selection programme since a number of sires are progeny tested. A manifold of sire indices proposed so far are simple daughter average index, corrected

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daughter average index, least squares method, maximum likelihood method, etc. with or without making adjustments for the number of daughters per sire. The least-squares analysis makes corrections for all environment effects in conjunction with the non-orthogonality in data. Different criteria like coefficient of variation (%), rank correlations, coefficient of determination (%) and error variance have been used to test the efficacy of different methods of sire evaluation (Singh, 2016).

The objective of the present investigation was to rank the sires based on the estimated breeding values of their daughters for first lactation traits.

MATERIALS AND METHODS

The performance records of 480 daughters of 41 sires spread over a period of 30 years from 1990-2019 were maintained at Instruction Dairy Farm (IDF) of G.B. Pant University of Agriculture & Technology, Pantnagar. The data were utilised to obtain the estimated breeding value of sires for first performance traits. The crossbred cattle belonging to eight genetic groups (Holstein Friesian × Red Dane × Sahiwal, Holstein Friesian × Jersey × Red Dane × Sahiwal, Jersey × Holstein Friesian × Sahiwal, Harijana × Sahiwal, Jersey × Sahiwal, Holstein Friesian × Jersey × Rathi × Sahiwal, Holstein Friesian × Rathi × Sahiwal and Holstein Friesian × Sahiwal) were considered for the present investigation. First lactation traits included were age at first calving (AFC), first service period (FSP), first calving interval (FCI), first lactation period (FLP), first lactation milk yield (FLMY), first lactation 305 days milk yield (FL305DMY), first lactation peak yield (FLPY) and first lactation days to attain peak yield (FLDAPY). Breeding values of sires for first lactation were estimated by Least squares model (Harvey, 1990) considering sire as random effect while season, period of calving and genetic groups as fixed effects. The effectiveness of LSM was judged by using Spearman's rank correlation and Pearson's product moment correlation. The following statistical model was used to estimate the breeding value of sires.

$$Y_{ijklm} = \mu + S_i + P_j + G_k + F_l + e_{ijklm}$$

Where, Y_{ijklm} = Observation on m^{th} progeny of i^{th} sire of j^{th} genetic group calved in k^{th} season and l^{th} period,

μ = Population mean, S_i = Random effect of i^{th} sire ($i = 1, 2, 3, \dots, 41$), L_j = Fixed effect of j^{th} genetic group ($j = 1, 2, \dots, 8$), G_k = Fixed effect of k^{th} season of calving ($k = 1, 2, 3$), F_l = Fixed effect of l^{th} period of calving ($l = 1, 2, \dots, 6$), e_{ijklm} = Random error was assumed to be normally and independently distributed with mean zero and constant variance i.e., NID (0, σ^2 s). The product moment and rank correlation for estimated breeding values among bulls for various first lactation traits were calculated according to the method proposed by Steel and Torrie (1980).

RESULTS AND DISCUSSION

In the present study, the estimated breeding values (EBVs) were estimated by least squares method and the sires were ranked subsequently (Table 1). The perusal of results under the present study unveiled the presence of large genetic differences between the breeding values of animals within the herd. The EBVs for sires ranged from 1143.24 days to 1408.33 days for age at first calving, 250.37 days to 275.52 days for first service period, 490.37 days to 516.38 days for first calving interval, 386.16 days to 398.13 days for first lactation period, 3052.27 kg to 4104.61 kg for first lactation milk yield, 2508.84 kg to 3102.25 kg for first lactation 305 days milk yield, 11.14 kg to 16.07 kg for first lactation peak yield and 31.72 days to 41.44 days for first lactation days to attain peak yield (Table 1). The average estimated breeding values for various first lactation traits were delineated in Table 2. The average estimated breeding value of bulls for age at first calving was 1277.18 days. The highest and lowest breeding values were 1408.33 days and 1143.24 days, respectively. The difference between the upper and lower estimates of breeding value was 265.09 days. The results revealed that there were 13 (31.70%) sires whose breeding values were above the average breeding value while 28 (68.30%) sires had their breeding values below the average breeding value. The average estimated breeding value of bulls for first service period was 263.65 days. The highest and lowest breeding values of sires were 275.52 days and 250.37 days, respectively. The difference between the upper and lower estimates was 25.15 days. The results revealed that there were 15 (36.50%) sires whose breeding values were above the average breeding value

Table 1: Expected breeding values of sires (EBVs) along with their ranks for first lactation traits by least square analysis

Sl. No.	Sire	No. of daughters	AFC (days)	Rank	FSP (days)	Rank	FCI (days)	Rank	FLP (days)	Rank	FLMY (kg)	Rank	FL305 DMY (kg)	Rank	FLPY (kg)	Rank	FLDAPY (days)	Rank
1	101	29	1392.14	37	265.09	22	516.38	41	390.37	20	3678.10	8	2970.27	9	13.20	34	38.51	38
2	102	40	1385.16	35	263.53	19	507.18	30	389.86	28	3272.41	37	2970.17	10	11.96	40	36.70	33
3	103	36	1408.33	41	261.16	14	503.18	18	386.16	41	3402.69	24	2688.63	37	12.72	37	36.00	26
4	104	35	1165.13	5	262.37	17	506.02	27	390.58	16	3492.77	18	2984.17	5	14.92	9	33.05	5
5	107	19	1301.36	28	261.65	16	508.06	33	388.76	34	3052.27	41	2891.77	15	11.14	41	32.24	3
6	110	11	1327.50	31	259.45	10	509.99	38	388.98	32	3389.08	26	2508.84	41	13.47	32	34.38	10
7	111	16	1394.07	38	259.82	13	506.58	29	391.68	12	3314.69	34	2838.31	21	12.52	39	33.94	7
8	114	5	1345.16	33	252.93	5	497.90	8	388.66	35	3300.45	36	2590.41	40	13.26	33	35.07	16
9	115	6	1287.70	25	273.44	39	504.73	24	391.37	13	3474.55	19	2704.70	36	13.82	29	35.87	25
10	116	9	1359.31	34	261.50	15	513.53	40	390.17	22	3307.38	35	2811.69	28	12.83	35	35.74	23
11	117	7	1271.36	20	253.15	6	497.50	6	390.17	22	3465.02	20	2713.72	35	15.15	6	33.65	6
12	118	8	1319.47	30	266.07	26	499.56	13	390.87	15	3432.78	23	2866.78	16	14.38	22	35.70	22
13	121	15	1257.02	17	271.98	36	502.39	16	387.22	39	3392.82	25	2855.89	19	14.04	27	35.17	18
14	122	5	1406.72	40	250.37	2	507.61	32	393.43	7	3682.37	7	2977.82	7	15.75	3	41.44	41
15	126	8	1278.25	22	275.52	41	499.84	14	390.54	17	3380.97	27	2958.87	11	14.20	25	36.07	30
16	127	10	1405.95	39	273.05	38	504.61	23	392.00	11	3499.41	17	2813.56	27	14.68	17	38.67	40
17	129	5	1389.26	36	268.11	30	496.18	5	386.44	40	3126.88	40	2800.29	30	13.73	30	31.72	1
18	132	17	1193.49	7	265.66	24	509.65	36	393.69	6	3589.88	13	2662.91	39	14.21	24	36.02	29
19	135	6	1168.18	6	274.54	40	503.47	20	394.29	4	3842.87	4	2999.53	4	15.29	4	38.07	36
20	137	12	1250.42	15	267.56	28	508.10	34	397.61	2	3767.31	5	2953.77	13	14.90	10	35.48	20
21	139	11	1262.91	18	252.02	4	497.58	7	388.12	37	3342.22	31	3102.25	1	14.72	14	36.68	32
22	142	8	1153.12	3	271.70	34	505.10	25	390.44	18	3356.60	29	2838.30	22	15.12	7	32.82	4
23	143	5	1252.28	16	259.53	11	498.29	9	387.95	38	3251.25	38	2806.15	29	12.76	36	34.43	11
24	145	10	1283.65	24	259.63	12	509.92	37	394.87	3	3705.14	6	2742.44	33	13.66	31	36.01	28
25	147	8	1247.24	14	263.87	20	490.37	1	390.26	21	3664.53	9	2831.08	24	14.86	12	34.88	12
26	150	6	1237.98	12	248.69	1	499.26	12	390.04	25	3315.72	33	2929.68	14	14.58	20	34.13	8
27	152	10	1275.32	21	257.08	8	499.09	11	392.74	8	3628.22	10	2763.06	31	15.16	5	38.06	35
28	155	16	1310.32	29	271.95	35	506.18	28	390.16	24	3622.13	11	2862.05	18	14.27	23	35.50	21
29	156	13	1290.67	26	264.39	21	503.62	21	388.99	31	3374.43	28	2814.84	26	14.56	21	37.73	34
30	157	7	1278.92	23	254.44	7	502.98	17	392.03	10	3500.35	16	2836.43	23	14.61	18	34.96	14
31	158	9	1295.06	27	265.91	25	498.72	10	389.44	30	3436.73	22	2829.81	25	14.69	15	36.16	31
32	159	5	1327.52	32	263.07	18	507.20	31	390.00	26	3343.01	30	2742.46	32	14.69	15	35.12	17
33	161	11	1153.06	2	269.56	32	490.45	2	394.26	5	3930.76	2	2734.71	34	15.95	2	32.22	2
34	162	12	1270.80	19	267.87	29	505.62	26	388.47	36	3594.67	12	2953.86	12	14.61	18	34.89	13
35	163	6	1225.26	10	268.28	31	508.55	35	388.78	33	3341.35	32	2864.98	17	12.56	38	38.18	37
36	164	15	1216.62	9	258.67	9	495.34	4	392.58	9	3548.86	15	2852.30	20	14.97	8	36.00	26
37	165	6	1246.47	13	251.24	3	494.16	3	390.39	19	3847.93	3	3056.34	3	14.75	13	35.00	15
38	166	7	1201.44	8	265.51	23	501.61	15	389.93	27	3213.20	39	2978.06	6	14.12	26	34.34	9
39	167	5	1229.60	11	267.00	27	503.35	19	389.85	29	3588.95	14	2665.51	38	14.87	11	35.40	19
40	169	6	1143.24	1	272.48	37	510.51	39	398.13	1	4104.61	1	3090.93	2	16.07	1	35.74	23
41	174	5	1156.94	4	269.94	33	504.24	22	390.91	14	3444.34	21	2970.58	8	13.84	28	38.58	39

AFC: age at first calving, FSP: first service period, FCI: first calving interval, FLP: first lactation period, FLMY: first lactation milk yield, FL305DMY: first lactation 305 days milk yield, FLPY: first lactation peak yield and FLDAPY: first lactation days to attain peak yield.

Table 2: Average expected breeding value (B.V.) of sires by least square analysis

Traits	Average B.V.	Max. B.V. (percent above average B.V)	Min. B.V. (percent below average B.V)	No. of sires over the average B.V. (percent of sires)	No. of sires below the average B.V. (percent of sires)
AFC (days)	1277.18	1408.33 (8.38%)	1143.24 (12.01%)	13 (31.70%)	28 (68.30%)
FSP (days)	263.65	275.52 (3.26%)	250.37 (6.16%)	15 (36.5%)	26 (63.50%)
FCI (days)	503.28	516.38 (2.85%)	490.37 (2.32%)	26 (63.40%)	15 (36.60%)
FLP (days)	390.76	398.13 (1.60%)	386.16 (1.45%)	11 (26.80%)	30 (73.2%)
FLMY (Kg)	3488.28	4104.61 (17.25%)	3052.27 (12.80%)	13 (31.70%)	28 (68.30%)
FL305DMY (Kg)	2849.46	3102.25 (9.33%)	2508.84 (11.58%)	23 (56.09%)	18 (43.91%)
FLPY (Kg)	14.22	16.07 (16.53%)	11.14 (19.2%)	29 (70.73%)	12 (29.27%)
FLDAPY (days)	35.61	41.44 (22.85%)	31.72 (5.95%)	35 (85.30%)	6 (14.7%)

while 26 (63.50%) sires had breeding values below the average breeding value. The average estimated breeding value of bulls for first calving interval was 503.28 days. The highest and lowest breeding values of sires were 516.38 days and 490.37 days, respectively. The difference between upper and lower estimates was 26.01 days.

The results revealed that the breeding values of 26 (63.40%) sires were above the average breeding value while 15 (36.60%) sires had breeding values below the average estimate. The breeding value of bulls for first lactation period was 390.76 days. The difference between the upper and lower estimates was 11.97 days. The results revealed 11 (26.80%) sires had their breeding values above the average breeding value while 30 (73.2%) sires had the estimates below the average breeding value. The average estimated breeding value of bulls for first lactation milk yield was 3488.28 kg. The highest and lowest breeding values were 4104.61 kg and 3052.27 kg, respectively. The difference between the upper and lower breeding values of sires was 1052.34 kg. The results revealed that were 13 (31.70%) sires with their breeding values above the average estimate while 28 (68.30%) sires had breeding values below the average breeding value. The average estimated breeding value of bulls for first lactation 305 days milk yield was 2849.46 kg. The highest and lowest breeding values were 3102.25 kg and 2508.84, respectively. The difference between the upper and lower estimates was 593.41 kg. The results revealed that the estimated breeding values of 23 (56.09 %) crossbred sires were above the average breeding value while 18 (43.91%) sires had their breeding values below the average estimate. The average estimated breeding

value of bulls for first lactation peak yield was 14.22 kg. The highest and lowest breeding values were 16.70 kg and 11.14 kg, respectively. The difference between upper and lower breeding value was 5.56 kg. The results revealed 29 (70.73%) sires had breeding values above the average breeding value while there were 12 (29.27%) sires with their breeding values below the average estimate. The average estimated breeding value of bulls for first lactation days to attain peak yield was 35.61 days. The highest and lowest breeding values were 41.44 days and 31.72 days, respectively. The difference between the upper and lower estimates was 9.72 days. The results revealed that there were 35 (85.30%) sires with their breeding values above the average estimate while 6 (14.70%) sires had their breeding values below the average breeding value.

The difference between two extreme breeding values indicated that LSM method discriminated amongst bulls for various first lactation traits. Large genetic differences between estimated breeding values of sires for lactation traits were also reported by Dubey and Singh (2014) and Bajetha and Singh (2015) in crossbred dairy cattle. Existence of large genetic differences between the animals might be attributed to the dissimilarities in their genetic groups, maintenance of animals in a close herd and perhaps, animals with truncated production might have not been culled from the herd. Dubey *et al.* (2014) evaluated Sahiwal and Crossbred sires for first lactation yield and concluded that to improve lifetime productivity major culling of bulls should be done on the basis of their daughter's first lactation milk yield. Bajetha and Singh (2015) compared different sire evaluation methods for ranking the sires using product moment and spearman rank correlation method and discerned that LSM was

Table 3: Estimates of Pearson's product moment correlation (below diagonal) and Spearman's rank correlation (above diagonal) among estimated breeding values of sires

Traits	AFC	FSP	FCI	FLP	FLMY	FL305DMY	FLPY	FLDAPY
AFC	1	0.50*	0.81*	0.56*	0.27	0.25	-0.56*	0.36
FSP	0.7	1	0.39**	0.48	0.43*	0.45	0.20*	0.45
FCI	0.52*	0.41**	1	0.53**	0.35**	0.21*	0.48*	-0.47
FLP	0.57	-0.32	0.42**	1	0.69**	0.34*	0.25	-0.52*
FLMY	-0.37*	0.44*	0.42	0.58**	1	0.35**	0.55*	0.33*
FL305DMY	0.24	0.31	0.21**	0.30*	0.33**	1	0.36*	-0.33
FLPY	-0.55	0.41*	0.32**	0.24	0.50**	0.37*	1	0.22*
FLDAPY	0.12	0.30	0.51	0.30*	0.23	0.38	0.27	1

** Significant at 1 % level ($P < 0.01$), * significant at 5 % level ($P < 0.05$); AFC: age at first calving, FSP: first service period, FCI: first calving interval, FLP: first lactation period, FLMY: first lactation milk yield, FL305DMY: first lactation 305 days milk yield, FLPY: first lactation peak yield and FLDAPY: first lactation days to attain peak yield.

Table 4: Sires (sire no.) of top 10 ranks on the basis of estimated breeding values of sires

Rank	AFC (Sire No.)	FSP (Sire No.)	FCI (Sire No.)	FLP (Sire No.)	FLMY (Sire No.)	FL305DMY (Sire No.)	FLPY (Sire No.)	FLDAPY (Sire No.)
1	169	150	147	169	169	139	169	129
2	161	122	161	137	161	169	161	161
3	142	165	165	145	165	165	122	107
4	174	139	164	135	135	135	135	142
5	104	114	129	161	137	104	152	104
6	135	117	117	132	145	166	117	117
7	132	157	139	122	122	122	142	111
8	166	152	114	152	101	174	164	150
9	164	164	143	164	147	101	104	166
10	163	110	158	157	152	102	137	110

the more efficient method of sire evaluation compared to BLUP method. Pandey *et al.* (2013) compared accuracy of contemporary comparison method (CC), least square method (LSM) and best linear unbiased prediction (BLUP) using coefficient of determination (R^2), coefficient of variation and rank correlation in Vrindavani cattle and noted that LSM was most efficient and accurate method of sire evaluation. Dubey and Singh (2014) evaluated sires considering first lactation yield for improvement of life time production in Sahiwal and crossbred cattle using rank correlation and product moment as a criterion for assessing the accuracy of LSM method for sire evaluation. Kumar and Singh (2021) used first lactation 305-day or less milk yield and individually part lactation records to estimate breeding value of Frieswal sires by using BLUP and LSM

and found that breeding value obtained by LSM method was more accurate and efficient than the BLUP method. Girimal *et al.* (2022) evaluated Sahiwal sires by comparing simple daughter average, Least squares method (LSM), Best linear unbiased prediction method (BLUP) and found that LSM method was equally important in evaluating the sires for first lactation 305-day milk yield. The accuracy of LSM in the present investigation was adjudged by using Pearson's (product moment) correlation and Spearman (rank) correlation as depicted in (Table 3).

The results affirmed that the product moment correlations among the EBVs of sires for first lactation traits ranged from low to medium and were statistically significant for most of the traits. The rank correlations between estimates of breeding values of sires based on first lactation traits

were low to medium and were statistically significant for most of the traits. This illustrated that ranking of sires would change from first lactation traits to future performance traits and therefore, sires should be judged for first time performance of their daughters to bring out genetic upliftment of sires. The rank of sires for first lactation traits against their EBVs (Table 4) implied that all sires would not rank same for all the traits. Similar results were also published by Singh *et al.* (2014), Bajetha and Singh (2015) and Kumar *et al.* (2015) in different cattle breeds.

Ranking of sires

Sire evaluation is generally intended at selecting first few top-ranking sires. Sires with top 10 ranks on the basis of their EBVs for first performance traits were depicted in table 4 and the results revealed the variation between the sires for all the traits. It could be concluded that sire numbers: 169, 167, 165, 135, 104, 117, 122, 152, 164 and 110 were the top 10 ranking sires by LSM method. The results indicated that sire superior in one trait might be inferior with respect to the other trait. Dubey and Singh (2014) and Bajetha and Singh (2015) opined that bulls should be selected based on the first lactation performance traits of their daughters. The results in the present investigation suggested that in order to improve the lifetime productivity, major culling of bulls of cow should be done on the basis of their daughter's performance.

CONCLUSION

These results suggested genetic variation between breeding values of sires for the first lactation traits. It was concluded that the estimated breeding values of sires had medium to high and significant product moment correlations (-0.37 to 0.58) and rank correlations (-0.56 to 0.81) among first lactation traits indicating least squares analysis as the efficient method for sire evaluation and ranking of sires in order to select the sires in breed improvement programme.

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